TRAINING PROJECT IN PEDOLOGY

KISII KENYA

An inventory of grasslands in the Kisii and part of the South Nyanza districts

PRELIMINARY REPORT NO 23

AGRICULTURAL UNIVERSITY
WAGENINGEN - THE NETHERLANDS

An inventory of grasslands in the Kisii and part of the South Nyanza districts

by

A.C. Plaizier

Preliminary Report no. 23

Frontcover: Cynodon nlemfuensis Vanderijst.

TRAINING PROJECT IN PEDOLOGY, KISII-KENYA
Agricultural University, Wageningen - The Netherlands

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Preface

This report of the Training Project at Kisii, Kenya, of the Section Tropical Soil Science of the Agricultural University of Wageningen, the Netherlands, is the twentythird one of a series to be presented to Kenyan Officials.
The Project started in November 1973 after assent had been granted by the Office of the President of Kenya.
It was meant to train post-graduate students of the Agricultural University of Wageningen and to furnish research opportunities to the staff. The activities of students and staff were directed to obtain a better knowledge of the soils and the agricultural conditions of the Project area to provide a basis for further agricultural development of the area.

The Project at Kisii was conducted by:

Ir. W.G. Wielemaker, teaching and research.

Ing. H.W. Boxem, management.

Visiting specialists from the Agricultural University of Wageningen helped to resolve special problems.

This report has been written by Mr. A.C. Plaizier.
The text has been corrected by Mr. W.G. Wielemaker. The aims of this report were to make an inventory list of the grassland plants and to study their palatability and furthermore to make a collection of these plants for the Herbarium of the Department of Plant Taxonomy of the Agricultural University of Wageningen, the Netherlands and for the Herbarium of Nairobi, Kenya.
Mr. Plaizier did this work being a post-graduate student of the University mentioned above from February up to August 1978 at the Training Project at Kisii, Kenya.

With these reports we hope to pay back a small part of the great debt we owe to Kenya in general and to many Kenyans in particular for their valuable contribution to the well-functioning of the Project.

The supervisor of the Project
J. Bennema, Professor of Tropical Soil Science.

SUMMARY.

In this report the palatability of pasture species - for stock - has been compared. A humid area in Kenya (the Kisii area) versus two (semi-) arid areas in West Africa resp. Niger (North-Sanam) and Upper-Volta (Léo).

It seems that the stage of a vegetation succession is strongly correlated with the grazing pressure. If grazing pressure is high in a certain area, that area will be classified down in vegetation succession stages and consists mainly of annual grasses.

It seems that the palatability of a vegetation is strongly correlated with a grazing pressure. If grazing pressure is high, the palatability of a grass vegetation will be small. This phenomenon acts in the comparison of the areas as well as in the areas.

One exception can be made. In the Kisii-Highlands the low stage of the grass vegetation consists of stoloniferous and rhizomatous grasses. This is because of the landscape and the high precipitation which causes a high erosion.
It is just luck that the stoloniferous and rhizomatous grasses found in the Kisii area are palatable ones.

1. Introduction.

This report consists of a comparison of grasslands in Kenya (Kisii-area, 80 km South-East of Kisuma), Upper Volta (Léo-area) and Niger-republic (North-Sanam).
The researches in Upper Volta and Niger-republic have been done respectively by B. Toutain (1973 - 1974) and B. Peyre de Fabrèques (1963).
In Kenya the research has been done by the author of this report (1978).
First the results of this last mentioned research will be given, then the comparison of the various areas.
The main difference between the grasslands in Kenya (Kisii) and the others is: in Kisii we find more or less cultivated grasslands, while the others are mainly natural ones.

1.1. Introduction to the Kisii-area.

The surveyed area has a surface of about 2450 km^2 and is situated between $0^{\circ}.30'$ - $0^{\circ}.85'$ S and $34^{\circ}.32'$ - $34^{\circ}.80'$ E (fig. 1).
In the North, East and in the Centre of the Kisii-area we find the Highlands (alt ± 2000 m), where most of the Kisii's live.
The population density is very high, about 350/km^2 and the population increase amounts to ca. 3 - 4% per year.
Before 1970 this district was exporting food- and cash crops to the other parts of the country, but nowadays they have to import food crops, especially maize.
The high population density is the reason for the more or less intensive exploitation of the available land and the scarcity of natural grassland.
In the South, on the border with the Masai-area, Kisii-farmers are renting land from the Masai for the growth of maize.

1.2. Present grasslands in the Kisii-area and the historical backgrounds of the Highland Grasslands.

The Kisii-area is situated at altitudes ranging from 1500 - 3000 m. with an annual precipitation of 760 - 2300 mm. (fig. 2).
Originally it was covered with Highland Forests, but nowadays, because of human occupation, it is covered with Pennisetum clandestinum and is called the Highland Grasslands.
Although this grassland has been classified as a Pennisetum-type, it is considered by Trapnell as a Themeda-type, which derives in the first place from an evergreen forest.
The Pennisetum species have taken over from Themeda triandra as a result of heavy grazing pressure and other biotic influences.
In the North, East and Centre of the Kisii-area the Highland Grasslands are found.
In the South and West of the surveyed area we find the Scattered Tree Grasslands.
The Scattered Tree Grasslands are divided (Bogdan and Edwards 1951) in:
the Acacia-Themeda-type in the South and the Low Tree-High Grass-type in the West. In the transitional belt between the Highland Grasslands and the Scattered Tree Grasslands, the dominating grass is Pennisetum hohenackeri. (syn. P. catabasis)
The transitional belt between the Acacia-Themeda-tye and Low Tree-High Grass-type is called Grouped Tree Grasslands.
Thus presently we encounter the Highland Grasslands (Pennisetum clandestinum) in the North, East and Centre and the Grouped Tree Grasslands (Pennisetum hohenackeri) in the South and the West.

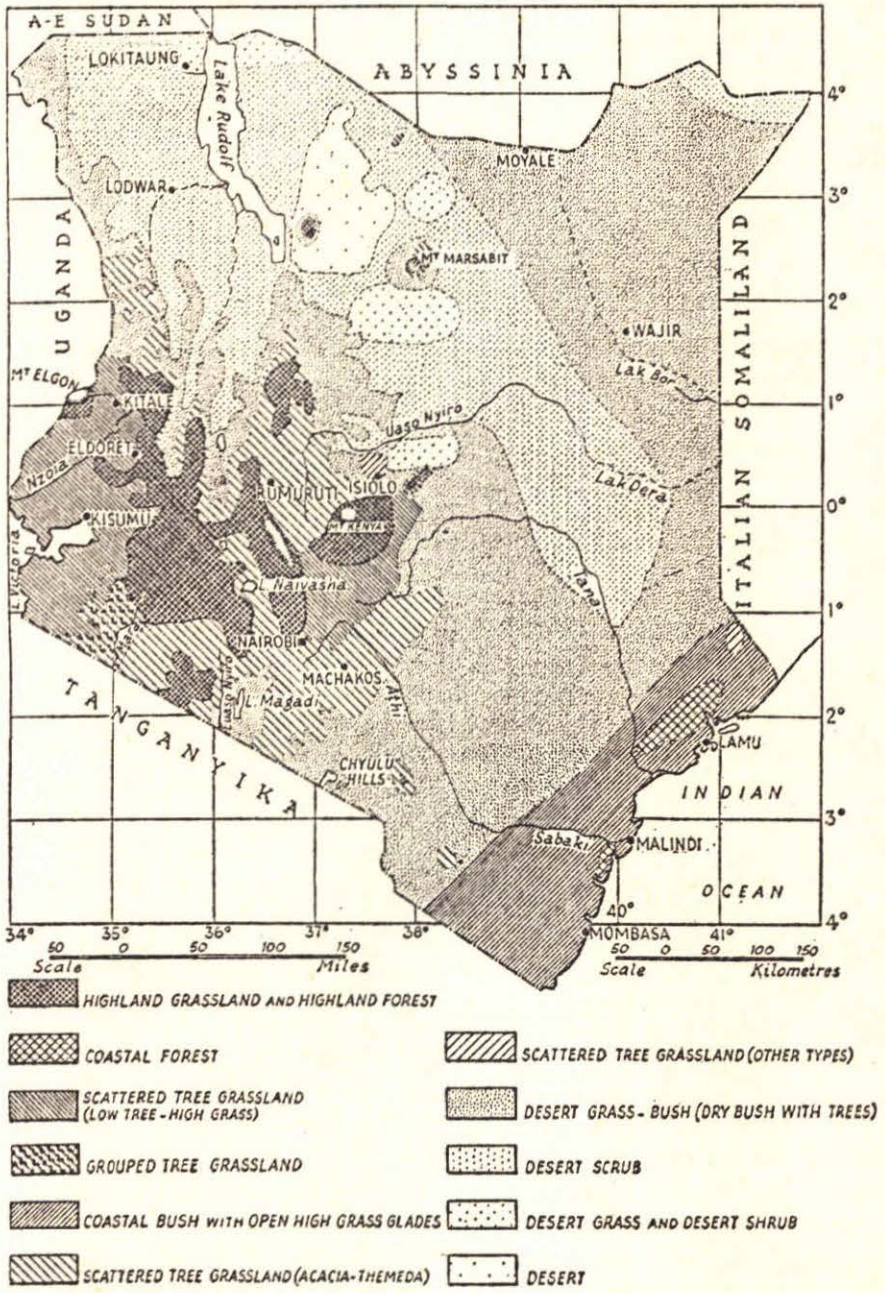


Fig.1 Vegetation Map of Kenya, Showing Natural Grasslands

1.3. Climate.

Rainfall as well as temperature and amount of sunshine are strongly correlated with altitude. This means that as a rule temperatures and average hours of sunshine per day decrease towards the Kisii-Highlands, while the amount of rainfall increases. Mountly temperatures near the shore of Lake Victoria (alt. ± 1150 m.) average 21° - 25° C, max. 33° - 37° C and minima 14,5° - 18° C.
In Kisii town the average monthly temperature fluctuates respectively between 18° and 22° C and 11° - 14° C.
Strong winds are rare, except at the start of a thunderstorm.

1.3.1. Rainfall.

The rainfall data are recorded at 18 stations. The data covering a period of 25 years have been precessed.
From the histogram (fig. 2) it is clear, that the rainfall is bimodal, especially towards the Kisii-Highlands. A short dry season occurs in June and July and a longer one in December, January and February.
The total annual rainfall decreases by 1800 mm. in the western part of the Kisii-Highlands to 800 mm. along the shore of Lake Victoria.
From the maximum amount in the western part of the Kisii-Highlands around Kisii township (Kisii: average is 1.912 mm., lowest 1.275 mm. and highest rainfall 2.325 mm.) towards the east, the rainfall decreases to 1.200 mm. at the boundary with Rift-Valley Province.

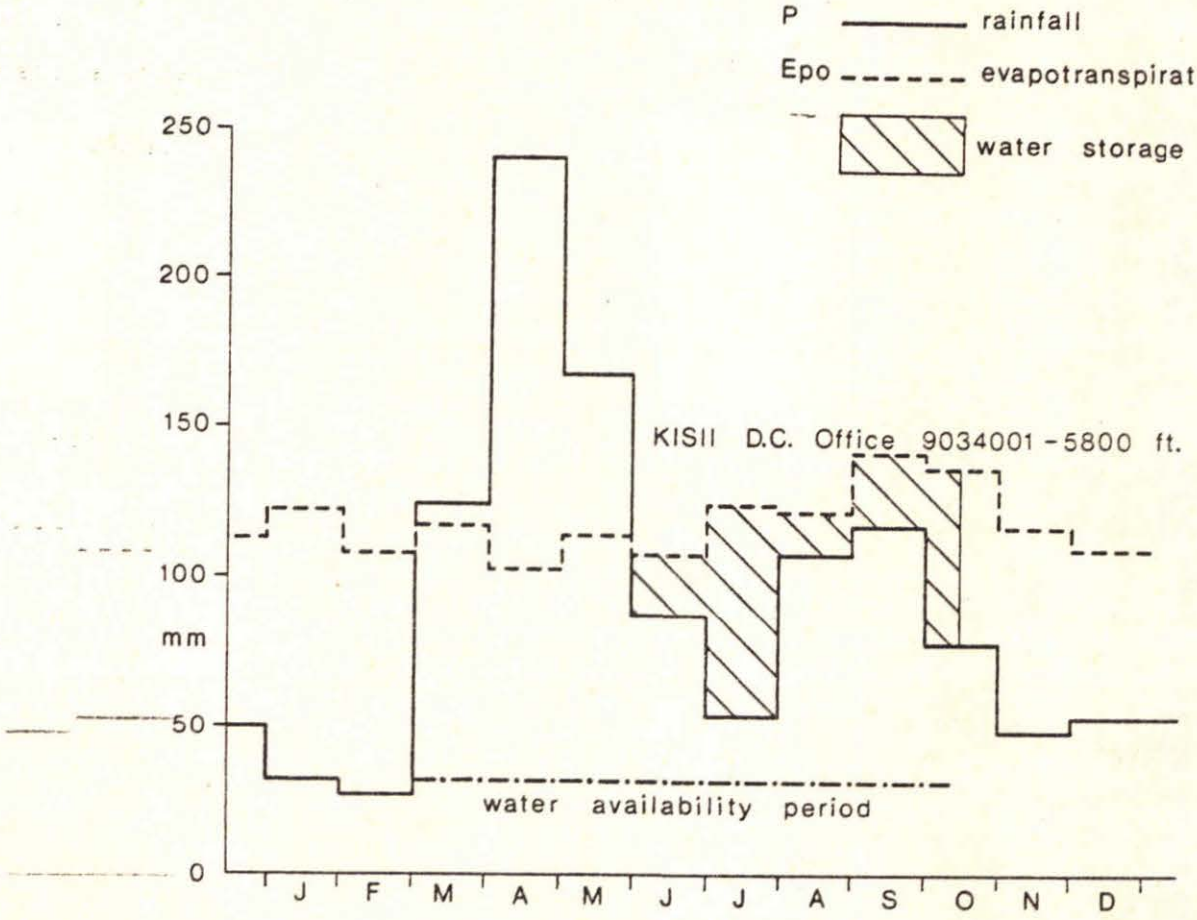


Fig. 2 Availability of water periods

1.4. Soils.

The following mapping-units (according to the reconnaissance map of the Kisii-area - mapsheet 130 -) are recognized; they can be grouped according to their soil characteristics as follows:

	Soil charateristics	Geomorphology	Mapping-units
1)	Somewhat excessively drained, shallow to moderately deep, dark red to dark reddish brown, (very) friable, rocky sandy loam to clay loam, with 10 (20) - 20 (40) acid humic topsoil.	Hills and minor scarps	HXP; U_1XhP; HBhP; $^1U_1$Qh.
2)	Well drained, deep reddish brown, friable clay with about 25 cm:		
	a. with acid humic topsoil....	Footslopes	FQh
	b. with humic topsoil.....	Uplands and Plateau remnants	U_2Ihn; U_3Ihn; U_4^2YhP.
3)	Imperfectly drained, shallow, dark reddish brown, friable sandy clay loam over petrophlinthite (murram); predominantly with acid humic topsoil; with inclusions of soil-type PXa.	Uplands and Plateau remnants	U_4GhM.
4)	Poorly drained, deep, black to dark grey very firm clay, abruptly underlaying 20 - 40 cm of silty loamy humic topsoil; calcareous in the deeper subsoil.	Plains	Ppa; PBd; PXa.
5)	Poorly drained, deep dark grey blight olive brown, mottled firm clay abruptly underlaying 30 - 70 cm of siltloam (with many iron manganese concretions at transitions).	Bottomlands and minor valleys	BXa_1; BXa_2; BXo.

2. Vegetation-types.

In the Kisii-area 41 sample plots have been choosen (appendix 1). On these plots, 10 x 10 m^2 each, the vegetation had a homogeneous character. Each of these plots has been surveyed thrice. During these surveys coverage of the species has been estimated and other facts as f.i. which type of fencing has been used, are noticed.
In appendix 3, showing the vegetation-table of the surveyed area, 4 vegetation-types have been recognized, partly according to the geomorphology as described earlier, partly according to human influence (arable use) on the soil. There is a positive correlation between human influence and soil-type / vegetation, namely:
In the bottomlands and plains we have a vegetation-type as a result of soil, climate and grazing.
On the shallow soils the vegetation-type is a result of grazing, erosion and climate.
The group of the cultivated grasslands (pastures) is a result of planting kikuyugrass and/or weeding in order to feed stock. These grasslands are mainly situated on minor slopes.
The fallows are used as grassland in their following period. The number of common weeds shows this clearly. These lands are situated on plateau remnants. The angle of inclination is very low.

2.1. Group of Bottomlands and Plains.

As described in chapter 1.2. of this report, there is a transitional belt between the Highland Grasslands and the Scattered Tree Grasslands. The natural grasslands in this transitional belt are partly situated in the bottomlands and plains.
Most of these bottomlands and plains have intermettently swampy conditions. The seasonal waterlogging is due to the very firm impermeable clay, which starts at depths of 20 - 60 cm.

Chapter 2.1.2. gives a comprehensive decription of the soil-types.

Rainfall as well as temperature are more or less constant along the border of the Highland Grasslands and are other conditions for this vegetation-type.

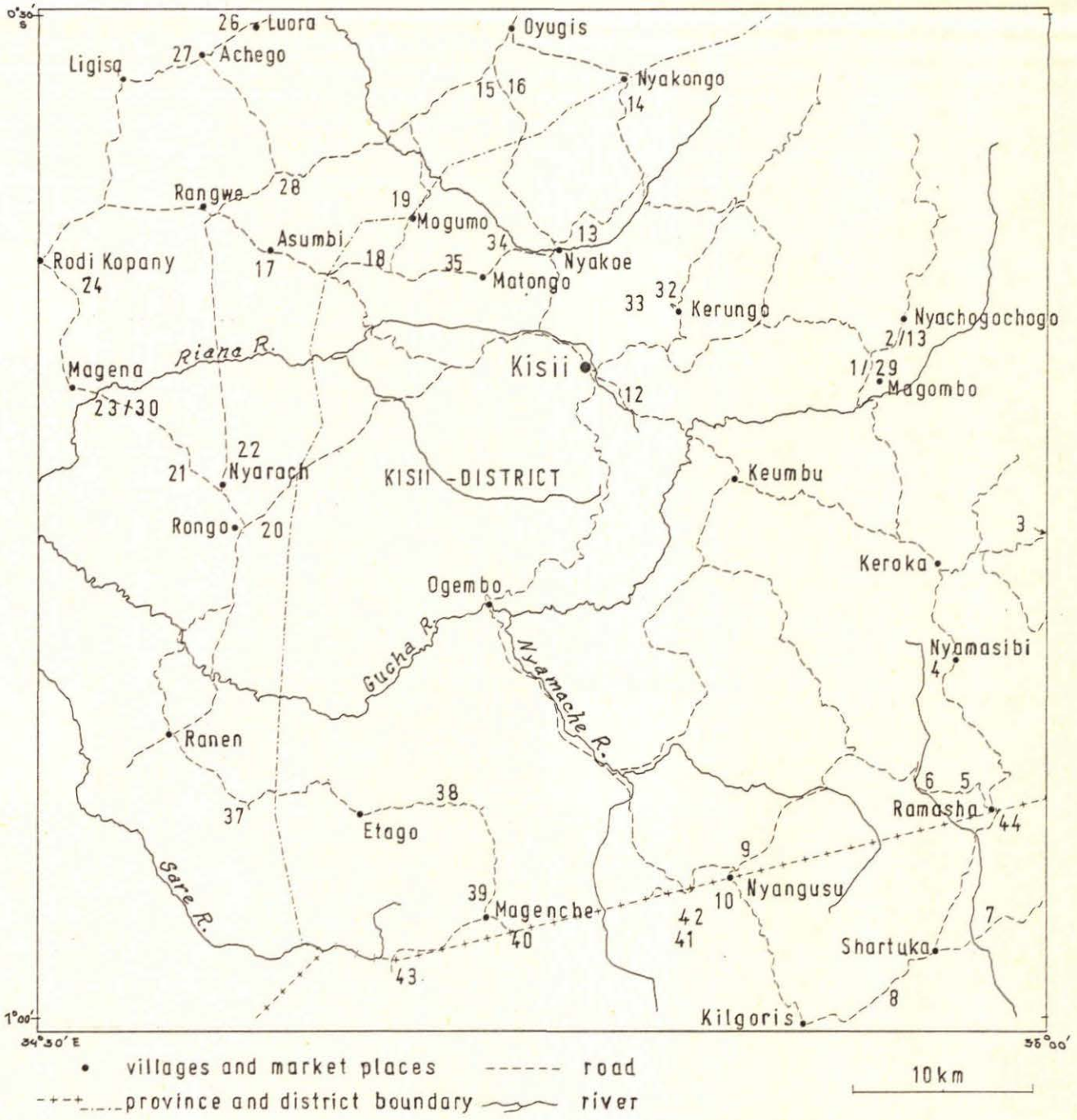
2.1.1. Species, coverage and palatability data.

See appendix 1.

2.1.2. Plot description.

(For situation of the plots see fig. 3 and appendix 2).

Fig. 3


0°30'S
1°00'
34°30'E
35°00'
26 Luora
Oyugis
Ligisa
27 Achego
Nyakongo
15 16
14
Rangwa
28
19
Mogumo
13
Asumbi
34
Rodi Kopany
24
17
18
35
Nyakoe
Matongo
33
32
Kerungo
Nyachogochogo
2/13
Riana R.
Magena
Kisii
1/29
Magombo
12
23/30
22
21
Nyarach
KISII - DISTRICT
Keumbu
Rongo
20
3
Keroka
Ogembo
Gucha R.
Nyamache R.
Nyamasibi
4
Ranen
6
5
38
37
Etago
Ramasha
44
9
Sare R.
39
Magenche
10
Nyangusu
42
41
40
Shartuka
7
43
8
Kilgoris
• villages and market places
province and district boundary
road
river
10 km

Plot no.:	Site:	Climate:	Mapping-units and soil characteristics:	Remarks:
7	Shartuka, plain. Natural grassland bordering Masai; not fenced.	Rainfall 1300 - 1400 mm. High April/May peak; mean min. temp. 10 - 13° C. range 17° C.	PPa: Poorly drained, deep, black, very firm clay, abruptly underlaying 20 - 40 cm of loamy humic topsoil; calcareous in the deeper sub-soil; in places very poorly drained.	Extensively grazed.
8	Shartuka, hill. Natural grassland bordering Masai Mara; not fenced.	see plot no. 7	FQh: A well drained, deep reddish brown; friable clay with about 25 cm humic topsoil.	Extensively grazed.
9	Nyangusu, bottomland. More or less natural grassland, on the border of Masai/Kisii-area; not fenced.	see plot no. 7	BXa_2: Poorly drained, deep dark grey to light olive brown, mottled firm clay, abruptly underlaying 30 - 70 cm of silt loam with many iron magenese concretions at transitions.	This plot consisted of a lower and a higher part. Grazing system: Transhumance.
15	Oyugis, bottomland. Natural grassland; not fenced.	Rainfall 1500 - 1700 mm. Main rainfall peak April/May.Jan./Febr. dry; mean. min. temp. 16° C. range 17° C.	BXa_1: Imperfectly to poorly drained, deep, dark grey slightly alkali firm clay, abruptly underlaying 20 - 50 cm silt loam.	The greater part of the year, rainwater is stagging in the field.
21	Rongo, plain. Natural grassland; not fenced.	Rainfall 1400 - 1650 mm. See plot no. 15.	U_4GhM: Moderately well drained, shallow dark reddish brown, friable sandy clay loam over petrophlinthite (murram); predominantly with acid topsoil; with inclusions of soil-type PXa.	In the U_4GhM part of this grassland termite hills be found. Grazing system: Transhumance.

Plot no.:	Site:	Climate:	Mapping-units and soil characteristics:	Remarks:
22	Nyarach; bottomland. Natural grassland; not fenced.	See plot 15	BXa_1: Imperfectly to poorly drained; deep dark grey slightly alkali firm clay, abruptly underlaying 20 - 50 cm, silt loam.	Situated in a small valley adjacent hills consist of arable land, giving a lot of weeds, seeds germinate in Febr.
23/30	Magena; plain. Natural grassland; not fenced.	Rainfall 1050 - 1550 mm. See plot 15	PXa: Poorly drained deep, dark grey, mottled firm clay, abruptly underlaying 20 - 40 cm of silt loam.	Plot. 23 has been cut for thatching. The regrow of the regrow of the vegetation has been studied.
24	Rody Kopany; plain. Somewhat disturbed natural grassland.	Rainfall 1050 - 1550 mm. main rainfall peak April, Jan. or Jan./Febr. and July dry; mean min. temp. 16° C, range 11 - 17° C.	PBd: Poorly drained, deep dark grey to grey, firm clay, with a fine structured humic topsoil.	Eragrostis tenuifolia, shows the big human influence.
40	Magenche; bottomland. More or less natural grassland; not fenced.	Rainfall 1600 - 2100 mm. see plot no. 7	BXa_2: See plot no. 9	Eucalyptus-trees have been planted in order to get a better drainage. It is also drained by means of ditches.
29	Magombo-valley; bottomland. Natural grassland not fenced.	Rainfall: 1500 - 2200 mm high April/May peak with continuous rainfall; mean min. temp. 10 - 13° C range about 17° C.	BXa_2: See plot no. 9	Greater part of the year flooded.

2.1.3. Discriminating species.

Appendix 3 shows the vegetation-table of the surveyed areas. In this group the most important discriminating grasses are:

Pennisetum hohenackeri
Eragrostis exaspera
Hyparrhenia rufa
Sporobolus pyramidalis
Leersia hexandra
Coelachne africana.

The most important discriminating sedges are:

Fimbristylis complanata
Fimbristylis dichotoma
Fimbristylis hispidula
Kyllinga sp.
Pycreus sp.
Scleria nutans.

The most important discriminating Leguminosae are:

Desmodium spp.
Crotalaria spp.
Indigofera spp.

The most important dicriminating herb is: Justicia anselliana.

The dominance of certain species depends on soil, soilfertility and grazing intensity. Although these grasslands have been classified as a Pennisetum-type, it is considered by Trapnell to have been a Themeda-type originally, derived in the first place from an evergreen forest.
The Pennisetum hohenackeri (syn. P. catabasis) have taken over from the Themeda as a result of heavy grazing pressure and other biotic influences.

2.2. Group of the Shallow Soils

This group of soils is characterised by shallow soils and belongs to the Scattered Tree Grassland community, mainly to the Low Tree - High Grass Type (1.2).
The shallow soils in this group can be found on the tops and steep slopes (>40°)of the hills.
As a result of erosion, caused by overgrazing, soil washed away and bare rocks remained.
The soil characteristics of this group consist of an excessively drained, mainly shallow (to moderately deep), dark red to reddish brown, friable, gravelly (rocky), sandy loam to clay loam, with a 10(20) - 20(40) acid humic topsoil. Chapter 2.2.2. gives a comprehensive description of the mapping-units and soil characteristics.

2.2.1. Species, coverage and palatability data.

See appendix 1.

2.2.2. Plot descriptions.

(For situation of the plots see fig. 3 and appendix 2).

Plot no.:	Site:	Climate:	Mapping-units and soil characteristics:	Remarks:
6	Ramasha; steep slope. Natural grassland; not fenced.	Rainfall 1400 - 1700 mm. High April/May peak with continuous rainfall; average min. temp. 10 - 13° C. range about 17° C.	U_1XhP: Excessively drained, mainly shallow, dark reddish brown, friable, gravelly clay with 15 - 30 cm humic topsoil.	Intensively used. Part of Loudetia kagerensis was rather low, probably caused by the high grazing pressure.
10	Nyangusu; steep slope. Natural grassland; not fenced.	Rainfall 1500 - 1800 mm. See plot no. 6	HXP: Excessively drained, very shallow, dark brown, very friable, rocky, sandy loam to clay loam, with 10 - 20 cm acid topsoil.	The coverage of Themeda triandra, Exotheca abyssinica and Loudetia kagerensis rather high, because this grassland is only used for the production of thatching.
14	Nyakongo, slope. Natural grassland; fenced with Cassia decapetala.	Rainfall: 1500 - 1750 mm. Average rainfall peak April/May with Jan. or Jan/Febr. dry; average temp. 16° C, range 11° - 17° C.	HBhP: Somewhat excessively drained, shallow to moderately deep, dark reddish brown, friable, gravelly clay, with 20 - 40 cm acid humic topsoil.	Fallow, but showing a vegetation, according to this group. Only 1 year fallow.
32	Manga ridge, slope. Natural grassland; fenced with barbed wire.	Rainfall: 1600 - 2100 mm. Average rainfall peak April/May; average min. temp. 10 - 13° C, range about 17° C.	U_1Qh: Well drained, deep to very deep, dark red to reddish brown, friable clay with 20 - 40 cm very acid humic topsoil.	Grassland, used for the production of thatching.
33	Manga ridge, top. Natural grassland; not fenced.	See plot no. 32	HXP: See plot no. 10	Grazing pressure is very high, therefore some characteristic species are missing.

Plot no.:	Site:	Climate:	Mapping-units and soil characteristics:	Remarks:
37	Ranen, slope. Natural grassland; not fenced.	See plot no. 14	HXP: See plot no. 10	Overgrazed and somewhat disturbed, caused by the fact that the adjacent fields are arable land.
41	Nyangusu, steep slope. Natural grassland; not fenced.	See plot no. 14	HXP: See plot no. 10	A decrease in the coverage of Themeda triandra, Brachiaria soluta and Digitaria abyssinica increase in Eragrostis tenuifolia caused by overgrazing.
42	Nyangusu, slope. Natural grassland; not fenced.	See plot no. 14	U_1XhP: See plot no. 6	Somewhat overgrazed, some weeds from the adjacent arable field are introduced here.
44	Ramasha, slope of a river-valley. More or less natural grassland.	Rainfall, 1500 - 2200 mm. See plot no. 14	U_1XhP: See plot no. 6	Overgrazed. This is clearly shown by the presence of Eragrostis tenuifolia, Sporobolus pyramidalis and Pennisetum hohenackeri.

2.2.3. Discriminating species.

Appendix 3 shows the vegetation-table of the surveyed area. In this group the most important discriminating grasses are:

Themeda triandra
Loudetia kagerensis
Setaria sphacelata
Brachiaria soluta
Exotheca abyssinica

The most important discriminating Leguminosae are:

Crotalaria spp.
Indigofera spicata
Indigofera volkensii.

This group of grasslands is classified as a Themeda-type as well. We can find back this characteristic grass in various plots, scattered over the surveyed area.
When grazing pressure increases, the coverage of Themeda triandra decreases. Some other grasses, as Loudetia kagerensis, Exotheca abyssinica, Digitaria scalarum and Eragrostis tenuifolia are taking the place of Themeda triandra in this vegetation type.
A stable Themeda vegetation degenerates into an unstable one with stoloniferous grasses as Digitaria scalarum and annuals as Eragrostis tenuifolia.
See chapter 2.5 about remarks of stoloniferous and rhizomatous grasses.
Mostly the substituted grasses are less palatable.

2.3. Group of the Cultivated Grasslands.

As mentioned above, the Kisii-area is a very densely populated area and nowadays natural grasslands are situated in less accessible areas as bottomlands, plains, on steep slopes and on tops of hills.
Because of the high population density and of its strong increase, most of the grasslands are cultivated.
The cultivation measures can be weeding only or planting with Pennisetum clandestinum (kikuyugrass) and weeding.
Kikuyugrass is an indigenous grass of the hihglands of East-Africa.
These pastures are mainly situated on slopes with a low angle of inclination. They have approximately the same altitude, 1600 - 2000 m, climate and soil-characteristics.
Chapter 2.3.2 gives a comprehensive description of the soil characteristics and climate.

2.3.1. Species, coverage and palatability data.

See appendix 1.

2.3.2. Plot descriptions.

(For situation of the plots see fig. 3 and appendix 2).

Plot no.:	Site:	Climate:	Mapping-units and soil characteristics:	Remarks:
3	Mwangorishill, flat slope. Fenced with Solanum aculeastrum and Cassia decapetala. Size 1 acre.	Rainfall 1500 - 2200 mm. High April/May peak with continuous rainfall. Average min. temp. 10 - 13° C. Range 17° C.	U_2Ihn: Well drained, very deep, dark red to reddish brown, friable clay with more than 30 cm humic topsoil.	About 15 years ago planted with P. clandestinum, if the sward is damaged Digitaria scalarum is on the increase. Weeded.
4	Nyamasibi, flat slope. Neither improved nor fenced. Size app. 1 acre.	See plot no. 3	U_1Ph: Well drained, deep to very deep dark reddish brown, friable, silty clay loam, with more than 30 cm humic topsoil.	About 7 years ago, this was arable land with maize. Cynodon nlemfuensis is distributed by stolons, a good indicator for the former state. Weeded.
5	Ramasha, slope. Fenced with Cassia decapetala. Size app. 1 acre.	Rainfall 1600 - 1800 mm. See plot no. 3	U_2Ihn: See plot no. 3	Weeded.
12	Kisii-town, flat slope. Fenced with barbed wire and Cassia decapetala. Size app. 1½ acres.	Rainfall 1600 - 2000 mm. See plot no. 3	U_2Ihn: See plot no. 3	Bare soil, as a result of the biological activity is very soon colonized by Digitaria scalarum. Weeded.
20	Rongo, flat slope. Fenced with barbed wire and Cupressus sp. Size app. 2 acres.	Rainfall 1500 - 1750 mm. Main rainfall peak April/May with Jan. or Jan./Febr. dry; average min. temp. 16° C, range 11 - 17° C.	U_4GhM: Moderately well drained, shallow to dark brown very driable, loamy sand to sandy loam over petroplinthite (murram); predominantly with an acid humic topsoil with PXa inclusions.	The high coverage of Sporobolus pyramidalis is probably caused by overgrazing.

Plot no.:	Site:	Climate:	Mapping-units and soil characteristics:	Remarks:
31	Nyachogochogo, slope. Fenced with Eucalyptus trees. Size app. 1½ acres.	See plot no. 3	U_2Ihn: See plot no. 3	About 20 years ago planted with Pennisetum clandestinum Digitaria scalarum and Paspalum scrobiculatum are fast colonizers. D. scalarum is preferred by cattle.
34	Matongo, flat slope. Fenced with barbed wire and Cassia decapetala Size app. 2 acres.	See plot no. 20	U_3Ihn: Well drained, very deep, reddish brown to red, fraible clay with more than 30 cm. humic or acid humic topsoil.	Improved about 10 years ago with Pennisetum clandestinum. Weeded.
35	Matongo, flat slope. Fenced with Cassia decapetala. Size app. 1/4 acre.	See plot no. 10	U_3Ihn: See plot no. 34	About 4 years ago this site was arable land, the reason of the high coverage of Cynodon nlemfuensis. Weeded.
38	Etago, slope. Fenced with Cassia decapetala. Size app. 2 acres.	Rainfall 1600 - 2100 mm.	HBhP: Somewhat excessively drained shallow to moderately deep, dark reddish brown, friable, gravelly clay with 20 - 40 cm acid humic topsoil.	Improved about 7 years ago with Pennisetum clandestinum. Against erosion terraces are made. Eragrostis tenuifolia shows the grazing pressure.
39	Magenche, slope. Fenced with Cassia Decapetala. Size app. 1½ acres.	See plot no. 38	FQh: Well drained, deep reddish brown, friable clay with about 25 cm humic acid topsoil.	Improved about 15 years ago with Pennisetum clandestinum. Eragrostis tenuifolia shows the grazing pressure.

2.3.3. Discriminating species

Appendix 3 shows the vegetation-table of the surveyed area. In this group the most important discriminating grasses are:
Pennisetum clandestinum
Cynodon nlemfuensis

and more or less: Digiteria scalarum.

The most important discriminating Leguminosae are:
Indigofera arrecta
Vigna parkeri
Trifolium baccarini
Trifolim semipilosum
Crotalaria incana.

The discriminating grasses are stoloniferous or stoloniferous/rhizomatous ones in this vegetation type: Chapter 2.5 is comprehensively dealing about stoloniferous and rhizomatous grasses. When the sward has been damaged by trampling or browsing, Pennisetum clandestinum is replaced by Cynodon nlemfuensis or Digitaria scalarum.
Only when there is little erosion in weakly undulating areas or when terraces have been made, Pennisetum clandestinum is replaced by Paspalum scrobiculatum or Eragrostis tenuifolia, respectively a perennial (tufted) and an annual grass.

2.4. Group of Fallow Lands.

This group consists of fallow lands and of some plots which are disturbed by human influence, because they are situated next to villages. To fertilize arable land in a natural way a fallowing period is necessary.
If there is a lack of manure or when chemical fertilizers are to expensive, a good alternative would be to let the land rest for some years. The fallowing period lasts a couple of years, at most 10 years.
F.i.: which crops have been grown or will be grown?
Sometimes when the fallowing period takes a long time, these lands are used as grazing lands and added up in a mixed farming system.
The vegetation has the character of a pioneer vegetation and consists of annuals or short living perennials.
The components of a pioneer vegetation are species which set up very quickly. These are mostly annuals or rhizomatous/stoloniferous grasses, depending on erosion (see chapter 2.3.3.).
In an existing vegetation, f.i. natural grasslands, when the sward is damaged frequently, there will be an extension of these types of grasses too.
When we know these fast colonizers, it will be possible to classify a natural grassland in its climax vegetation and to qualify a pasture in relation to the weedification.

2.4.1. Species, coverage and palatability data.

See appendix 1.

2.4.2. Plot descriptions.

(For situation of the plots see fig. 3 and appendix 2).

Plot no.:	Site:	Climate:	Mapping-units and soil characteristics:	Remarks:
16	Oyugis, not fenced.	Rainfall: 1500 - 1700 mm. Main rainfall peak April/ May with Jan. or Jan./ Febr. dry; average min. temp. 16° C, range 11 - 17° C.	U_4YhP: Well drained, moderately deep to deep, reddish brown friable clay, predominantly with humic topsoil.	Fallow, for about 1 year.
17	Asumbi, not fenced.	See plot no. 16.	U_4YhP: See plot no. 16.	Status uncertain, Pennisetum hohenackeri is present. Probably disturbed.
18	Nyamatutu, fenced with barbed wire and Cassia decapetala.	See plot no. 16.	U_3Gh: Well drained, deep dark red, friable clay with 20 - 40 cm humic topsoil; in places gravelly.	Fallow, for about 2 years.
19	Mogumo, not fenced.	See plot no. 16	U_4YhP: See plot no. 16.	Status uncertain, if it lies fallow, than at least 5 years.
25	Ligisa, fenced with Aloe laterita.	Rainfall: 1200 - 1500 mm. Main rainfall peak in April/May with Jan. or Jan./Febr. dry; average min. temp. 16° C. range 11 - 17° C.	U_4YhP: Somewhat excessively drained, mainly shallow, brown, friable gravelly loam, predominantly with humic topsoil.	Fallow, for 1 year.
27	Achego not fenced.	See plot no. 25.	U_4YhP: See plot no. 25.	
36	Ranen, not fenced.	See plot no. 16.	U_4YhP: See plot no. 16.	Fallow, for 3 years. Somewhat disturbed too.

2.4.3. Discriminating species

Appendix 3 shows the vegetation-table of the surveyed area. In this group the most important discriminating grasses are:

Rhyncheletrum repens
Digitaria longiflora
Aristida adoensis

More or less: Digitaria scalarum.

The most important discriminating Leguminosae are:

Tephrosia linearis
Zornia pratensis
Crotalaria spp.
Indigofera spp.

The characteristic grasses as Digitaria longiflora and Digitaria scalarum are stoloniferous ones.
Aristida adoensis, Hackelochoa granularis, Perotis patens are annuals. Another grass that indicates the instability of a vegetation is Sporobolus pyramidalis, which is an element of the Group of Bottomlands and Plains.
This grass too, is frequently found in this vegetation.

2.5. Discussion.

In the preceding chapters and in appendix 3 a clear division between the Kisii-grasslands has been made.
The various geomorphological areas have their own vegetation type, which has resulted from human influences and man's stock. These influences are (over)grazing and burning too frequently.

Shallow Soils.

The group of the Shallow Soils possesses more or less the character of a native grassland, in which Themeda triandra and Loudetia kagerensis dominate. Whyte (1974) and Bayer (1955) call these grasslands with T. triandra as dominant grass a sub-climax vegetation, which is greatly due to frequent burning and a climax vegetation respectively. Bayer (1955) referred to vegetation in South Africa, encountered by the Boeren in 1700, but at that time the natives were already accustomed burning their grasslands frequently. The vision of Whyte (1974) seems to be correct up till now, that most of the African grassland vegetation is subclimax vegetation arisen by frequent burning.
The coverage of 45% of L. kagerensis (in the Group of the Shallow Soils) shows that these grasslands are on the verge of being overgrazed (Whyte 1974, table 4/3).
In short, grasslands belonging to the Shallow Soils vegetation type are grazed heavily and deteriorating phenomena are shown clearly with a high coverage of L. kagerensis.

Bottomlands and Plains.

A same account can be held for the vegetation type of the Bottomlands and Plains. Just as the Themeda triandra vegetation in the Group of the Shallow Soils, this is a Themeda triandra vegetation, which has been derived from the Evergreen Forests (Rattray 1960). The grazing quality of the North Mara Grasslands has deteriorated greatly due to uncontrolled grazing and burning.

Course, wiry, tufted grasses as Pennisetum hohenackeri, Aristida adoensis and Sporobolus pyramidalis have become dominant over wide areas. This vegetation type has been shown comprehensively in this report.

Kikuyugrass pastures (stoloniferous and rhizomatous grasses).

Previously it has been noticed that Pennisetum clandestinum (kikuyugrass) is an East-African indigenous grass.
This grass is found between the altitude of 1500 - 3000 m. with a rainfall of 760 - 2300 mm. in the East-African Highlands. The natural grasslands in these Highlands are called a Pennisetum-type. This Pennisetum-type too is a degenerating stage of the Evergreen Forests.
Rattray (1960) distinguishes the next succession stages:

Evergreen Forest Themeda triandra Pennisetum clandestinum.

As described before, Pennisetum clandestinum possesses rhizomes and stolons. In general we find grasses with rhizomes and stolons in an instable environment (personal communication Doing en Ketner).
F.i. in areas with a variable watereconomy or in areas with abrupt poor/rich soils.
In the Netherlands, dunes of the Agropyron - Rumicion - crispi community are illustrative examples. In these dunes, now and then washed over by sea-water, a stoloniferous grass as Agrostis stolonifera and a stoloniferous herb as Potentilla anserina (Rosaceae) have been able to develop extensively, because of the variable habitat. Of course there are more examples.
In areas with a seasonal waterlogging many rhizomatous Cyperaceae are found as well. (see chapter 2.1.)
It is known from Australia that temporary flooded bogs are covered with Cynodon dactylon (R.M. Moore, 1970).
On diversifying rich/poor soils we come across stoloniferous and rhizamatous plants.
The Noordberg (Renkum) is an example of this last mentioned fact. On the border with the river Rhine and the footslope of this hill, there is suddenly an extensive occurrence of Cynodon dactylon.
Soils that are easily replaced (eroded) have an instable character too.
In the Kisii-area, an area with a high amount of rainfall and an undulating landscape, erosion will be great and if soil coverage is damaged, open spots appear.
Grasses with a stoloniferous or rhizomatous habitus can develop just there, in casu Pennisetum clandestinum, Cynodon nlemfuensis and Digitaria scalarum.
Ecological profit resembles clearly.
As a rule annuals occupy vacant spots in a vegetation. Chapter 2.4.3. gives clearly that fast colonizers of fallow lands are annuals. However in an environment as we encounter in the Kisii-area, many of the aforsaid characters are present and stoloniferous and rhizomatous grasses are able to set up.
This is why the succession of serial stages of Evergreen Forests Themeda triandra annuals is in this case:

Evergreen Forests Themeda triandra stol./rhiz. grasses.

It is just luck that Pennisetum clandestinum has a rather high nutritional value and compared to other natural grasses it has a high yield too.
These are the reasons why most of the Kisii-farmers plant kikuyu grass, when they want a permanent grassland. Most of the time planting material is collected in natural areas of Kisii.

Fallow Lands.

As a rule arable lands are situated on slopes which are not too steep. This is logical, because no one likes to find back his crops in a valley after a thunderstorm.
Firstly the main coverage is brought by annuals as Digitaria longiflora, Aristida adoensis, Hackelochloa granularis and by Digitaria scalarum, a stoloniferous perennial. This last mentioned grass is a difficult weed to destroy, because of its stolons. (Communications with Kisii-farmers)
Secundly by perennials as Rhyncheletrum repens and Paspalum scrobiculatum. P. scrobiculatum is a prostrate grass and very easily spread by seeds. It is rather well grazed despite of its low habitus.
In a fallow land of a couple of years old the coverage consists mainly of Digitaria scalarum and Paspalum scrobiculatum.

3. Palatability and coverage of the Kisii-Grasslands.

At the same time, when a vegetation survey was made on a certain site, on the same site palatability data were collected. Similarly coverage was estimated.
The palatability data are put in a liked - eaten - disliked scale; coverage in a 1 - 100% scale.
The numerical data are given in table 1 and 2, and in appendices 1 and 4.

Table 1.

	Group I (Bottomlands & Plains)	Group II (Shallow Soils)	Group III (Pastures)	Group IV (Fallows)
Gramineae				
tot. number of species	37	26	22	26
number liked	11	13	9	9
number eaten	9	4	4	2
number disliked	10	8	8	11
unknown	7	1	1	4
Cyperaceae				
tot. number of species	20	3	10	9
number liked	2	-	-	1
number eaten	-	1	2	7
number disliked	18	2	8	1
unknown	-	-	-	-
Leguminosae				
Papilionaceae				
tot. number of species	15	7	13	19
number liked	-	-	1	3
number eaten	1	2	2	-
number disliked	14	4	9	15
unknown	-	1	1	1
Mimosaceae				
tot. number of species	1	1	-	-
number liked	-	-	-	-
number eaten	-	-	-	-
number disliked	1	1	-	-
unknown	-	-	-	-
Caesalpiniaceae				
tot. number of species	1	2	5	4
number liked	-	-	-	-
number eaten	-	-	-	-
number disliked	1	1	5	4
unknown	-	1	-	-

		Group I	Group II	Group III	Group IV
Rest					
Herbs					
tot.	number of species	43	26	51	38
	number liked	-	-	-	-
	number eaten	5	2	3	-
	number disliked	37	24	48	37
	unknown	1	-	-	1
Woody					
tot.	number of species	24	21	17	27
	number eaten	2	-	7	-
	number disliked	20	19	10	27
	unknown	2	2	-	-
Unknown					
tot.	number of species	3	5	5	10
	number disliked	3	3	5	8
	unknown	-	2	-	2
Total number of species		144	91	123	133
	number liked	13	13	10	13
	number eaten	17	9	18	9
	number disliked	104	62	93	103
	unknown	10	7	2	8

We see that all vegetation types have about the same number of species, the Shallow Soils however are an exception. Specific differences among the vegetation types can be found in the distribution of the number of species, classified by the most important families.
As mentioned above, the Shallow Soils are an exception in relation to the number of species found on the grasslands.
They have a fewer number of species compared with the rest of vegetation types and the average number of species, found in each plot, is also very low, about 20. (see appendix 2)
This is probably caused by the fact, that these soils have a more native vegetation, shown by Themeda triandraand Loudetia kagerensis.
But table 1 gives more notable facts:

1° The number of Cyperaceae on the Bottomlands and Plains is rather high, but Cyperaceae are normally found in habitats like these.

2° The ratio Herbs / Woody plants is nearly 1 on the Shallow Soils. This is a normal situation on native grasslands, because the climax-vegetation consists of perennials.
The ratio Herbs / Woody plants is 3 : 1 in the Pastures. As mentioned above, weeding is a normal management activity and plants, which are disliked, are weeded.
This is evidently shown by the high number of woody plants eaten.

3° In general the number of species liked or eaten is very low in the Kisii-grasslands.

In order to get a deeper understanding of the palatability of the Kisii-grasslands, it is better to calculate which part of the coverage is liked or eaten. (Table 2)

In this table has been calculated from appendix 4, which part of the coverage is liked or eaten. The following conclusions can be made:

1° The Shallow Soils and the Pastures are clearly favoured above the Bottomlands and Plains and above the Fallow lands.
On the Shallow Soils 75% of the coverage is liked and consists of:
Loudetia kagerensis
Themeda triandra
Brachiaria soluta

On the Pastures 65% of the coverage is liked and consists of:
Pennisetum clandestinum
Digitaria scalarum
Paspalum scrobiculatum
Cynodon nlemfuensis

On the Fallows 54% of the coverage is liked and consists of:
Paspalum scrobiculatum
Digitaria scalarum

On the Bottomlands and Plains 39% of the coverage is liked and consists of:
Paspalum scrobiculatum
Kyllinga sp.

Table 2: Average Palatability.

	Group I (Bottomlands & Plains)	Group II (Shallow Soils)	Group III (Pastures)	Group IV (Fallows)
Gramineae				
average coverage	73	82	75	72
average liked %	27	74	61	52
average eaten %	3	4	8	3
Cyperaceae				
average coverage	19	1	2	-
average liked %	12	1	-	-
average eaten %	3	-	1	-
Leguminosae				
average coverage	2	2	8	5
average liked %	-	-	4	2
average eaten %	-	-	2	-
Rest				
average coverage	6	15	15	23
average liked %	-	-	-	-
average eaten %	3	-	-	-
Total				
coverage	100	100	100	100
average liked %	39	75	65	54
average eaten %	6	4	11	3

2° We can conclude that native grasslands as they are found on the Shallow Soils are preferred to the others.
About 75% of the vegetation is liked, in contrast with another group of native grasslands viz. the Bottomlands and Plains, in which 39% of the vegetation is liked. As stated earlier, the Shallow Soils and the Bottomlands and Plains have derived from:

Evergreen Forests — Themeda triandra { Pennisetum hohenackeri, in the Bottomlands and Plains / Loudetia kagerensis, on the Shallow Soils

and deteriorating of these grasslands is caused by human influences and man's stock; on the Bottomlands and Plains this is very obvious. We can conclude that continuing an intensive grazing management is a critical case.

3° Whyte (1974), Rattray (1960) studied an indigenous clover (Kenyan White Clover) Trifolium semipilosum of this area.
It is a clover with a good N_2-fixation, however it is a low plant and contributes but little to the foodsupply of the stock.
This table shows that half of the coverage of Leguminosae is liked in the Pastures and that Trifolium semipilosum is responsable for it, appendix 1.
About 4% of the total coverage of the Pastures is formed by Kenyan White Clover. It is a pity that the Kisii-farmers are not interested in this usefull plant.

4° An important sedge of the Bottomlands and Plains is Kyllinga sp.; it accounts for 12% of the palatable species of this vegetation.

5° As we saw in table 1, a cultivation measure as weeding can be distinguished too in this table. It results in species, which are eaten. About 11% of the coverage is eaten in the Pastures.

In short we can say that of the number of species in the Kisii-Grasslands only a few are preferred.
But compared with the coverage of the species liked and eaten, the grasslands on the Bottomlands and Plains and on the Fallow Lands are clearly retarded in relation to the Shallow Soils and the Pastures.
Although the Pastures are improved, the coverage of the palatable species is lower than the coverage of the palatable species on the Shallow Soils.
The natural grasslands on the Shallow Soils are very valuable and should be treated with care.

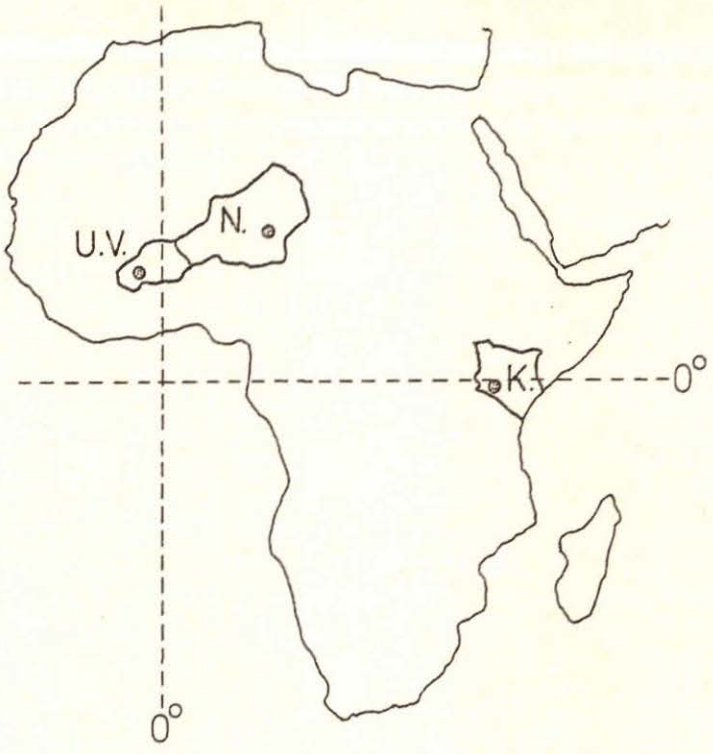
4. Introduction to various surveyed areas.

Part II of this report consists of a comparison between grasslands of this Niger-republic (North-Sanam), Upper-Volta (Léo) and Kenya (Kisii).

Fig. 4 shows the various areas on a geographical map.

The surveyed area of the Niger-rep. is situated between: $3^{\circ}.30'$ - $4^{\circ}.10'$ E; $15^{\circ}.10'$ - $15^{\circ}.40'$ N.
The surveyed area of Upper-Volta is situated between: $1^{\circ}.35'$ - $2^{\circ}.13'$ W; $11^{\circ}.04'$ - $11^{\circ}.45'$ N.
The surveyed area of Kenya is situated between: $34^{\circ}.32'$ - $34^{\circ}.80'$ E; $0^{\circ}.30'$ - $0^{\circ}.85'$ S.

Fig. 4.



The areas have a surface of about 2500 km^2 each, but the climatical circumstances in the different areas are rather variable.

	annual rainfall	number of dry months	average temp.
Niger-rep.	320 mm.	9 - 11	42° - 15° C.
Upper-Volta	1030 mm.	7	31° - 25° C.
Kenya	1800 mm.	4 - 5	22° - 18° C.

Before the vegetation of these areas will be compared, first some words in order to get a deeper understanding, why these areas are compared. The basic environmental factors that determine the composition of f.i. a grass community are soil, climate, exposure, altitude and slope. In addition to these relatively permanent factors, there are others which are in a constant state of change in nature and intensity.
Under their influence, some species become rare or absent, and new ones more adapted to the new conditions take their place.
Although the overall picture is still patchy due to lack of sufficient analysis over the whole intertropical zone, some preliminary indicators are already appearing. There are certain species which are usually found high in the vegetation serial stages in the absence of the intensive operation of use factors.
As grazing intensity increases, the more palatable species will be reduced in percentage cover; the bunch grasses of the climax will be damaged because of their slow growth habit, which becomes exposed to defoliation at an earlier, more critical stage than the other, more rapidly growing perennials in the same community.
Then there is a group of species that always appears to belong to lower stages in succession; it is tough and less palatable and adapted to greater soil aridity.

There are the pyrophytes that are resistant to fire, or may even be stimulated by it. Finally, there are the annuals representing the last-ditch attempt of a genus to perpetuate itself in conditions in which its perennial ancestors can no longer persist. (Whyte, 1974)
About the annuals another few words:
The taxonomic and historical origin of annual forms of the Gramineae is of fundamental importance in any study of the origin of cereals.
Most botanists agree that annual forms of plant species arose from perennials.
Annuality is a mechanism for escaping seasonally unfavourable environments.
The change of a species population from the perennial to the annual state happens as an expression of the physiological stress produced by such environments - great or increased intensity of desiccation and heat over long periods of time, which occasionally happened and possibly in different places in geobotanical history, or adverse seasonal temperatures associated with higher latitudes and altitudes.
Perennials tend more towards vegetative growth, since reproduction by seed is not so essential to their continued existence. Annuals must produce large amounts of seed to allow for wastage, and the seeds are larger to help the next generation to become established in an inhospitable environment. The evolution of annual forms of specific or lower status from a perennial favours dispersal of that genus into new habitats in which the perennial forms could not grow.
The annual forms of the Gramineae are characteristic, particularly of arid and semi-arid habitats, and are increasing in frequency with the progressive extension of man-induced desiccation.
Heteropogon contortus is predominantly perennial in India, but an annual form is found in arid ecological niches on the Maharashtan Deccan.
The occurence of annual forms of this genus in the absence, untill recently, of the perennials in Java (Monod de Froideville 1968) is to be explained in terms of adventitious introduction. The more equable environments of the humid tropics are not conductive to the evolution of the annuals.
Although annual species of Gramineae may occur in small percentages in arid and semi-arid communities, (The Grasses and Pastures of S.A., 1955; Moore 1970), their presence as dominants in such habitats must be regarded with suspicion. They are then probably secondary and low in ecological regression.
The climax grass communities around deserts or in (semi)-arid zones generally are perennial (Rattray 1960) these growth forms may be progressively eliminated due to overgrazing, spasmodic cultivation and other causes, and replaced by less demanding secondary annuals of the same, but more commonly other genera.

4.1. Presence of species in the various grazing areas.

As stated in the introduction in this chapter, we encounter 2 types of annuals on the (semi)-arid grazinglands.

1° In natural areas a small part of the vegetation consists of adapted annual grasses.

2° In deteriorated areas a part of the vegetation consists of annuals too, and usually we find the more general genera as f.i. Aristida.
Whyte (1974) a.o. suppose that in the natural area of Kisii hardly any annuals are found.

It will be significant to compare the numbers of annuals versus perennials in the semi-arid area of Niger, in the semi-humid area of Upper-Volta and in the humid area of Kenya.

Table 3:

Presence of species in a grazing-area of Niger-republic (North-Sanam).

	annual	perennial herbs	perennial shrubs/trees	total
Gramineae	62	8	-	70
Cyperaceae	4	4	-	8
Leguminosae				
Caesalpiniaceae	3	2	5	10
Mimosaceae	1	-	12	13
Papilionaceae	23	2	-	25
Rest	96	13	23	132
Total	189	29	40	258

Presence of species in a grazing-area of Upper-Volta (Léo).

	annual	perennial herbs	perennial shrubs/trees	unknown	Total
Gramineae	39	43	-	-	83
Cyperaceae	12	3	-	-	15
Leguminosae					
Caesalpiniaceae	3	-	14	-	17
Mimosaceae	-	-	15	-	15
Papilionaceae	27	10	5	11	53
Rest	63	37	97	13	210
Total	137	93	131	32	393

Presence of species in a grazing-area of Kenya (Kisii).

	annual	perennial herbs	perennial shrubs/trees	unknown	total
Gramineae	11	28	-	15	54
Cyperaceae	5	16	-	9	30
Leguminosae					
Caesalpiniaceae	2	2	2	2	8
Mimosaceae	-	-	1	-	1
Papilionaceae	9	15	-	20	44
Rest	58	85	24	17	184
Total	85	146	27	63	321

The numerical data are mentioned in table 3.
From this table some percentages are calculated.
The grass vegetation of North-Sanam (Niger) consists for 88% of annuals.
The grass vegetation of Léo (Upper-Volta) consists for 47% of annuals.
The grass vegetation of Kisii (Kenya) consists for 35% of annuals.
However, the value of the date of semi-arid and humid areas are not exactly the same, because in hot (semi-) arid areas, malpractices such as grazing and trampling of the same area continuously at the same time every year by large concentrations of game or domestic stock have resulted in a reduction of the grass components to the lowest stage of succession very quickly (in some cases in 2 or 3 years) and under heavy rainfall conditions, the grass cover is generally much more tolerant of abuse and takes longer to decteriorate and recovery is assisted by the more reliable rain (Rattray, 1960).
Thus by the prevailing climatical conditions the carrying capacity of the Kisii-grasslands is much higher than of both areas of West-Africa.
However a reasonable part of the grass vegetation of Kisii consists of annuals and it will be significant to investigate on what kind of grasslands the greater part can be found.
From appendix 1 we can calculate that 1/3 part of the 35% has come from the groups of the Bottomlands and Plains and from the Shallow Soils. Although the carrying capacity of the natural grasslands of Kisii is higher, they are found at least half way down in the serial successsion stages, on account of the characteristic vegetation (see chapters 2.1.3., 2.2.3. and 2.5.) and of the part of annual grasses.

The grazing lands of North-Sanam and Léo can be compared easily, because they are situated in app. the same ecological zone:
The destructive change on these lands can be described in simplified terms (Riney, 1963):

1. An original stand of comparatively closely spaced vigorously perennial grasses with an almost complete cover of litter between the grass bases.

2. Decrease in amount of litter and in vigour of perennial grasses and amount of ground covered by perennials.

3. As bare ground increases, pedestalling of grasses develops in some soil types; in locations favourable to the growth of shrub and trees, woody vegetation begins colonising the bare patches of ground at an accelerated rate. Soil loss increases.

4. Bare ground continues to increase, accelerated bush encroachment increases, thickets develop, large scale soil loss develops via wind or water erosion. Grasses at this stage are predominantly annual grasses.

5. Run-off progressively increases with thickening of the dendritic stream pattern and rapid back cutting of newly formed gullies. Sheet wash or dune formation develops on a large scale in some areas. Available surface water is greatly decreased, once permanent streams become intermittant through silting.

6. Land ultimately has to be abandoned from any productive type of utilisation which depends on perennial grasses.

With aid of this scale and the data of Peyre de Fabrègues (1963) and of Toutain (1974) the surveyed West-African grasslands can be classified as follows:

- Data of Peyre de Fabrègues.
  - = Dune formations and sandy accumilations are occurring much in the surveyed area.
  - = 88% of the grasses are annuals.

Table 4:

Palatability of species in North-Sanam - grazing area - Niger-republic arranged to the most important families.

	Liked	Eaten	Disliked	Total
Gramineae	17	46	5	68
Cyperaceae	2	6	-	8
Leguminosae	-			
Caesalpiniaceae	-	5	5	10
Mimosaceae	-	8	4	12
Papilionaceae	3	14	8	25
Rest				
Herbs	3	37	71	111
Woody	-	9	9	18
Total	25	125	102	252

Palatability of species in Léo - grazing area - Upper-Volta arranged to the most important families.

	Liked	Eaten	Disliked	Total
Gramineae	49	11	23	83
Cyperaceae	-	-	14	14
Leguminosae				
Caesalpiniaceae	-	2	14	16
Mimosaceae	-	3	12	15
Papilionaceae	4	1	47	52
Rest				
Herbs	1	1	108	110
Woody	-	14	87	101
Total	50	31	310	391

Palatability of species in Kisii - grazing area - Kenya arranged to the most important families.

Gramineae	20	9	10	39
Cyperaceae	2	1	20	23
Leguminosae				
Caesapliniaceae	-	-	7	7
Mimosaceae	-	-	1	1
Papilionaceae	3	5	33	41
Rest				
Herbs	-	7	142	149
Woody	-	-	13	13
Total	25	22	226	273

- Data of Toutain.
  - = Soils have become erosion susceptible.
  - = On terraces, summits and slopes of hills, there is an extension of a woody vegetation. Evidently shown in table 4. In Léo, 33% of the species are woody ones, while the vegetation of North-Sanam consists of only 16% woody species.
  - = 47% of the grasses are annuals.

The Léo-area can be classified in the above mentioned Riney-scale in category 3-4, while North-Sanam belongs to category 5.
The Grasslands of Léo are liable to a destructive change and are half-way down in the succession-stages.
The Grasslands of North-Sanam are nearly down in the succession-stages.

5. Palatability of grasslands in Niger, Upper-Volta and Kenya.

5.1. Introduction.

As described in the introduction of chapter 3, a deteriorating of the natural grasslands is attended with a change of the coverage of the more palatable species towards the less palatable ones.
But it is possible to describe vegetation succession stages whether based on the presence of palatable species or not.
The advantage of comparing grasslands in this way is, that collected data can be compared at once, without using all kinds of correction factors, as contrasted with what we saw in chapter 3, where we had to take account of the prevailing climate of the different areas.

5.2. Palatability of species in North-Sanam, Léo and Kisii.

The numerical data about the palatability of the species in the surveyed areas are shown in table 4.

Some conspicuous things can be noted:

- The increase in the number of Cyperaceae.

Niger	8
Upper-Volta	14
Kisii	23

As known most of the Cyperaceae are found in the most humid areas of the world. The surveyed areas accord to this understanding.

- The increase in the number of Gramineae Niger - Upper-Volta and the sudden decrease in Kenya.

Niger	68
Upper-Volta	83
Kisii	39

De Wit (1978) made an inventory of the Serengeti-plains (Tanzania), about 350 km. S. of Kisii and he too encountered a low number of grass species. (about 52)

- The paucity of woody species in Kisii accords to the way in which the vegetation surveys have been taken. Only grasslands have been sampled. Trees and taller shrubs have not been considered in the inventory of the Kisii-grasslands, because of their little importance.

- The large number of Papilionaceae in Léo, Kisii and North-Sanam. A group of genera belonging to this family (and also some genera of the Caesapliniaceae and Mimosaceae) as Tephrosia, Indigofera, Crotalaria (and Cassia) are composed of rugged, unpalatable and even toxic indicators of overgrazing and are below the grass-dominant communities in the succession towards bare soil (Whyte, 1974).

Presence in Léo		Presence in Kisii*		Presence in North-Sanam	
Cassia	7	Cassia	4	Cassia	7
Crotalaria	10	Crotalaria	7	Crotalaria	4
Indigofera	10	Indigofera	-	Indigofera	5
Tephrosia	4	Tephrosia	9	Tephrosia	9
	31 = 46%		20 = 44%		25 = 72%

- The pro rata contribution of these species eaten respectively liked is written below:

	Eaten	Liked
North-Sanam (Niger)	10%	50%
Léo (Upper-Volta)	13%	8%
Kisii (Kenya)	9%	8%

* Counted in the natural areas on the Bottomlands and Plains and on the Shallow Soils.

It can be concluded that the Leguminosae species in North-Sanam belonging to the category liked are preferred, probably caused by the low coverage of the liked grasses (table 5).

5.3. Palatability of the grasslands to the coverage.

Tacitly this report is dealing about grasslands without a definition of grasslands. That is why a definition of grasslands will be given.
"As stated in the Unesco-classification the term grassland is used for vegetations, in which grasses are governing the herbs layer, i.e. the coverage of grass-like herbs amounts more than 50%.
Beside grass-like herbs, shrubs and trees are in evidence, but the coverage of these woody species is not allowed to cross 40%, otherwise the regarding vegetation is classified in another formation-type".
The surveyed areas accord to this claim; table 5.
However the percentage of grasses actually liked is much lower than the coverage.
The percentages liked vary from 36% in Niger, 45% in Upper-Volta to 54% in Kisii.

The main grasses liked in Niger are:

Aristida funiculata
Aristida mutabilis
Brachiaria distichophylla
Brachiaria hagerupii
Brachiaria lata
Echinochloa colonum
Eragrostis tremula
Schoenefeldia gracilis
Sehima ischaemoides
Sporobolus cf. helvolus

Table 5:

Comparing the palatability of grasslands in Niger, Upper-Volta and Kenya, to the coverage of the species.

	Niger (North-Sanam)	Upper-Volta (Léo)	Kenya (Kisii)
Gramineae			
average coverage	70	61	76
average liked %	36	45	54
average eaten %	9	8	5
Cyperaceae			
average coverage	7	-	6
average liked %	-	-	3
average eaten %	7	-	1
Leguminosae			
average coverage	7	23	4
average liked %	1	-	2
average eaten %	2	7	1
Rest			
average coverage	16	16	14
average liked %	1	-	-
average eaten %	3	8	1
Total			
average coverage	100	100	100
average liked %	38	45	59
average eaten %	21	23	8

The main grasses liked in Volta are:

Andropogon pseudapricus
Andropogon ascinoides
Andropogon gayanus var. bisquamulatus
Andropogon gayanus var. gayanus
Hyparrhenia dissoluta
Hyparrhenia involucra
Hyparrhenia rufa
Hyparrhenia smithiana
Hyparrhenia subplumosa
Imperata cylindrica
Microchloa indica
Monocymbium ceresiiforme
Oryza longistaminata
Paspalum orbiculare
Pennisetum pedicellatum
Schizachyrium comiguense
Schizachyrium platyphyllum
Setaria anceps
Sorghastrum trichopus
Sporobolus pyramidalis

The main grasses liked in Kenya are:

Brachiaria soluta
Chrysochloa orientalis
Cynodon nlemfuensis
Digitaria scalarum
Eragrostis atrovirens
Eragrostis kiwuensis
Hyparrhenia rufa
Loudetia kagerensis
Paspalum scrobiculatum
Pennisetum clandestinum
Setaria atrata
Setaria sphacelata
Sporobolus pyramidalis
Themeda triandra

To complete this food-parcel stock or game is pointed to species less palatable but possible to graze.

The main grasses eaten in Niger:

Aristida adcensionis
Eleusine indica
Hyparrhenia dissoluta
Lasiurus hirsutum
Schizachyrium exile
Tragus racemosa

Volta:

Beckeropsis uniseta
Ctenium newtonii
Echinochloa stagnina
Loudetia simplex
Tripogon minimus
Veteviria nigritana

Kenya:
Brachiaria brizantha
Digitaria longiflora
Eragrostis tenuifolia
Panicum maximum

In the food-parcel of stock or game other species than grasses contribute too. F.i. the high coverage of the legumes in Upper-Volta is remarkable. As shown in chapter 4.1. about 40% of the species belong to genera which are known as toxical or unpalatable and as reflected here only a small part is eaten.
Liked or eaten species, other than grasses are in the different areas:

Main species liked in Niger:

Cyperus congomeratus	Cyperac.
Cyperus rotundus	Cyperac.
Commelina forkalaei	Commellinac.
Tribulus terrestris	Zygophyllac.
Alysicarpus ovalifolius	Papilionac.
Stylosanthus mucronata	Papilionac.
Zornia glochidiata	Papilionac.

Upper-Volta: -

Kenya:

Kyllinga erecta	Cyperac.
Kyllinga sp.	Cyperac.
Triflolium semipilosum	Papilionac.

Main species eaten in Niger:

Blepharis linariaefolia	Acanthac.
Bauhinia rufescens	Caesalpinac.
Bulbostylis barbata	Cyperac.
Fimbristylis exilis	Cyperac.
Monosonia senegalensis	Geraniac.
Gisekia pharnacioides	Molluginac.
Lemeum diffusum	Molluginac.
Mollugo cerviana	Molluginac.
Mollugo nudicaulis	Molluginac.
Crotalaria podacarpa	Papilionac.
Thephrosia purpurea	Papilionac.

Upper-Volta:

Annona senegalensis	Annonac.
Saba senegalensis	Apocynac.
Bombax costatum	Bombacac.
Afzelia africana	Caesalpiniac.
Daniella olieveri	Caesalpiniac.
Dyospyros mespiliformis	Ebenac.
Strychnos spinosa	Loganiac.
Khaya senegalensis	Melinac.
Acacia dudgeoni	Mimosac.
Pterocarpus erinaceus	Papilionac.
Securidaca longepedunculata	Polygalac.
Gardenia erubescens	Rubiac.
Gardenia tricantha	Rubiac.
Vitellaria paradoxa	Sapotac.

Kenya:

Spilanthus mauritiana	Compositae.
Trifolium baccarini	Papilionac.
Vigna parkeri	Papilionac.
Spermacoce princei	Rubiac.

A well known household word is as follows: "Hunger is the best sauce", and as shown this word serves in this situation too.
Firstly there is a weak tendency in the catagory of Gramineae. In the area with the lowest coverage of palatable grasses 9% is liked, in the area with highest coverage of palatable grasses only 5% is liked.
Secondly, there is a strong tendency of this phenomenum in the total-class of table 5.
It can be concluded that the lower the coverage of species actually liked, the higher the coverage of species actually eaten.

5.4. Main disliked families.

A large part of the vegetation is disliked. In the different areas some families, partly inhabiting all areas, partly area specific, are disliked because of their morphological or chemical composition.

Families, hardly/not eaten:	Reason:
1. Generally distributed	
Caesalpiniaceae	The main species are woody or grow-height is to low; sometimes containing poison glyco-alkaloïds.
Compositae	Most species are woody or somewhat hairy.
Euphorbiaceae	Most species have a poisonous latex.
Papilionaceae	Main species of the main genera contain poison glyco-alkaloïds.
Cyperaceae	Consist of perennials, mainly rugged or their habitat is inaccessable.
2. Area specific	
Niger:	
Amaranthaceae	Most species are woody and/or hairy.
Asclepiadaceae	Most species have poisonous latex and are hairy.
Boraginaceae	Most species have rough leaves.
Upper-Volta:	
Combretaceae	Main species are woody.
Moraceae	Main species are woody.
Kenya:	
Labiatae	Main species are woody.
Umbelliferae	Grow-height of the main species is to low.

6. Conclusions.

Some matters of fact are clearly shown in the foregoing chapters of this report. To the grassvegetations in the different areas two values are attached:
1° An agricultural value - palatability for stock.
2° A biological value - succession vegetations.

As stated by the several authors, in the different areas a climax vegetation consists of perennials and forests.
Naturally only a few annuals are part of a climax vegetation and then particularly in (semi-) arid areas.
However when a vegetation consists of many annuals, disturbing influences can be recognized, which degrades a climax vegetation to - in the worst case - bare soil.

ad. 1: Palatability for stock.
When a grassland deteriorates by malpractices as overstocking etc. and many annuals colinize a sward, this is attended with a fall of the number and of the coverage of the more palatable species.
In the short life-cycle of annuals the vegetative period - the period, in which grass is most palatable - is short.
This is one of the essentials of the fall of the palatability of a grassland.
In undermentioned table these facts are lined up:

	Number of grasses	number of annuals	perc. of annuals
Niger	68	62	91
Upper-Volta	83	39	47
Kenya	39	11	28

	coverage of grasses	coverage of annuals liked	coverage of perennials liked
Niger	70	36	-
Upper-Volta	61	9	36
Kenya	76	-	54

If the percentage of annuals decreases, the percentage and the coverage of perennials liked increases.

Table 6 illustrates clearly that in Upper-Volta perennials are much more preferred than annuals.
The ratio number of per./number of ann. = 2
The ratio cov. of per. liked/cov. of ann. liked = 4
One can conclude that this is an actuating motive why f.i. an overgrazed grassland deteriorates very quickly.
The perennials are preferred and annuals or disliked perennials (remind the less palatable tufted perennial Pennisetum hohenackeri in the Bottomlands and Plains of the Kisii-area) can extend on the cost of the more palatable perennials.

ad. 2: Biological value.
In the foregoing two succession vegetations have been distinguished:

Evergreen Forests* - perennials - disliked per. -
stoloniferous and rhizomatous grasses

annuals

* Probably not in (semi-) arid areas.

Whether the majority of grasses is annual either stoloniferous/rhizomatous or doesn't depend on the environment. In Kenya the pitch of the matter is on stol./rhiz. grasses because the landscape undulates and the percipitation is rather high so that, by means of erosion, a habitat is created in which these types of grasses can thrive well, while in other areas with little soil replacement the main point is on the annuals.

Table 6:

Comparing the number of species of Gramineae, eaten in Niger, Upper-Volta and Kenya, split up to the biological form.

	number of annual species (cov.)	number of perennial species (cov.)	number of unknown species	Total
Niger:				
liked	17 (36%)	- (-)	-	17
eaten	42	4	-	46
total	59	4	-	63
Upper-Volta:				
liked	16 (9%)	33 (36%)	-	49
eaten	3	8	-	11
total	19	41	-	60
Kenya:				
liked	- (-)	18 (54%)	2	20
eaten	4	5	-	9
total	4	23	2	29

One can conclude that in both cases the vegetation is far down in the succession, although the palatability of the stoloniferous and rhizomatous perennials is higher, on account of the more vegetative growth.
In Kenya Pennisetum clandestinum a stol./rhiz. grass gives evidence of a very important vegetative growth.
The inflorescences of this grass are much reduced, only some anthers and stigmas are coming out of the leaves.

However it is possible to classify the three compared areas in two ways as follows:

1° To their arable value:
1. Kenya - 59% of the total coverage is liked, 8% is eaten.
2. Upper-Volta - 45% of the total coverage is liked, 23% is eaten.
3. Niger - 38% of the total coverage is liked, 21% is eaten.

2° To their biological value:
1. Kenya/Upper-Volta - halfway down in the succession.
2. Niger - far down in the succession.

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Appendix 1.

All plants mentioned in this appendix have been collected and can be found in the herbarium (WAG) of the:

Laboratory of Plant Taxonomy,
Generaal Foulkesweg 37,
WAGENINGEN
The Netherlands

In this appendix all species have been arranged to their family and of every species is mentioned:

a. scientifical name (or only the collectionnumber - collection Plaizier -).
b. the biological form classified to: ah - annual herb
ph - perennial herb
shr - shrub.

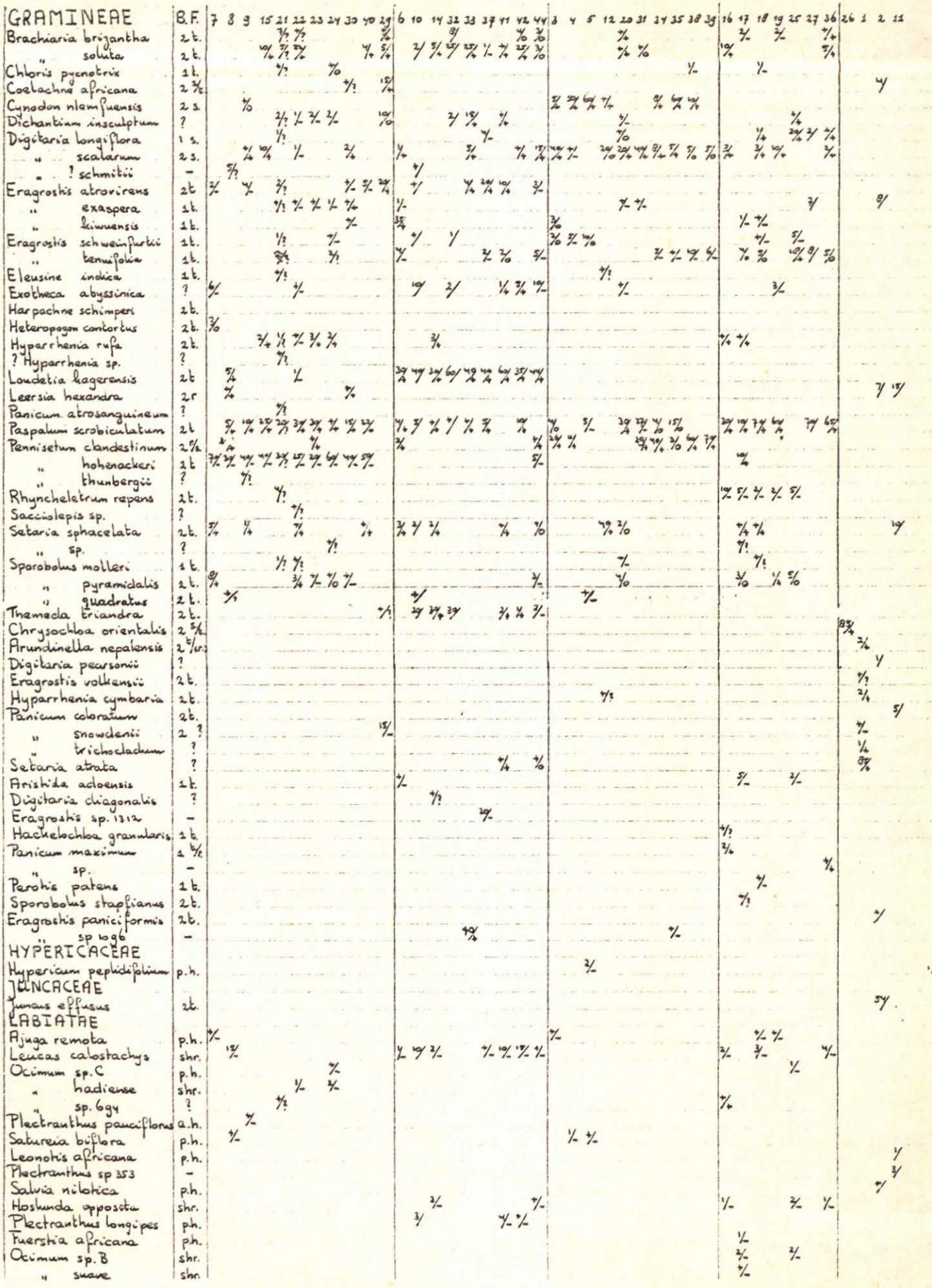
The grasses and sedges are classified to:
1 - annual
2 - perennial
r - rhizomes
s - stolons
s/t - stolons/tufted
r/s - rhizomes/stolons

c. coverage: above slant (/).
d. plot numbers: (refer to the sites in appendix 2).
e. palatability data, below slant (/), classified to: + = liked
o = eaten
- = disliked.

APPENDIX 1

	B.F.	7	8	9	15	21	22	23	24	30	40	29	6	10	14	32	33	37	41	42	44	3	4	5	12	20	31	34	35	38	39	16	17	18	19	25	27	36	26	1	2	22
ACANTHACEAE																																											
Dyschoriste radicans	a.h.					½				½			¼		½							½		½						½	½										½			
Justicia anselliana	p.h.	¼	½	½	½	½		¼	½																																	
Thunbergia alata	p.h.					½									½									½											½								
Justicia sp.	–								½																																	
Justicia betonica	p.h.																								½																½		
Justicia heterocarpa	a.h.																																							½		
Hypoestes verticillaris	p.h														½						½																					
Justicia flava	p.h																		½																							
Justicia pinguior	p.h.														½																											
Phaulopsis imbricata	a.h.														½										½																	
Asystacia laticapsula	p.h.																							½			½	½	½					½								
Justicia exigua	a.h.																																	½	½	½	½					
Justicia striata	a.h.																						½																			
Ruellia patula	p.h.																								½																	
AMARANTHACEAE																																							½			
Celosia argentina	a.h.																								½																	
Achyranthus aspera	a.h.																																									
ASCLEPIADACEAE																																										
Stathmostelma pedunculata	a.h.	½																							½																	
Gomphocarpus semilunatis	p.h.																																									
APOCYNACEAE																																							½			
Carissa edulis	shr.																																									
BALSAMINACEAE																																								½		
Impatiens nana	a.h.																																									
BORAGINACEAE																																										
Cynoglossum coerulcum	p.h.												½																													
lanceolatum	a.h.																				½																					
CAESALPINIACEAE																																										
Cassia mimosoides	a.h.					½	½	½	½	½					½									½	½		½					½	½	½								
" bicapsularis	shr.																																						½			
Cassia parva	p.h.																																							½		
" sp.	–																		½																				½		
" decapetala	shr.																								½																	
Cassia sp. B	a.h.																									½									½							
Tylosema fassoglensis	p.h.																								½	½										½		½				
Cassia sp. 982	–																																		½		½					
CAMPANULACEAE																																										
Lobelia minutula	p.h.											½											½																			
Monopsis stellaroides	p.h.											½											½																		½		
COMMELINACEAE																																										
Aneilema hockii	p.h.							½	½																															½		
Commelina africana	p.h.						½		½						½				½						½										½							
" subulata	a.h.				½						½																															
Commelina reptans	p.h.														½									½	½												½				½		
" benghalensis	a.h.																																									
CRASSULACEAE																																										
Crassula gravihii	p.h.																																							½		
Crassula absinoides	a.h.																						½																			
COMPOSITAE																																										
Ageratum conyzoides	a.h.					½	½						½										½		½			½	½		½	½	½	½						½	½
Aspilia mossambicensis	p.h.		½	½		½								½	½					½	½		½			½					½	½	½	½		½				½	
Aspilia pluriseta	p.h.					½								½												½							½	½		½					
Blumea aurita	a.h.					½	½		½						½																	½									
Carduus chamaecephalus	a.h.	½											½								½																					
Chrysanthellum americanum	a.h.								½																	½																
Conyza hochstetteri	p.h.			½			½								½											½															
" newii	p.h.	½	½																					½					½												
Crassocephalum vitellinum	p.h.	½		½							½	½		½	½				½				½	½	½		½	½		½		½		½				½		½	
Elephantopus scaber	a.h.						½	½			½								½																			½			
Emilia integrifolia	a.h.						½																			½									½	½						
Erlangia cordifolia	a.h.	½																																	½	½						
Helichrysum globosum	p.h.	½									½									½				½					½	½											
Senecio discifolius	a.h.					½																														½						
Sphaeranthus suaveolens	ph.	½																																			½			½	½	
Spilanthus mauritiana	a.h.	½		½							½														½	½	½	½	½	½	½										½	
Tagetes minuta	a.h.			½																				½		½			½						½						
Vernonia glabra	p.h.						½	½	½																		½					½	½			½	½				
Bidens pilosa	a.h.																							½	½															½	
Cirsium buchwaldii	p.h.											½																													
Dichrocephala chrysanthemifolia	a.h											½											½																		
Helichrysum foetidum	a.h																				½																		½		
" schimperi	shr.																																						½		

	B.F.	7	8	9	15	21	22	23	27	30	40	29	6	10	14	32	33	37	41	42	44	3	4	5	12	20	31	34	35	38	39	16	17	18	19	25	27	36	26	1	2	22
Hoenelia vernonioides	shr.																																							½		
Sigesbeckia abyssinica	a.h.																																							½		
Pilloselloides hirsuta	p.h.														½																												
Tridax procumbens	a.h.																	½																									
Conyza floribunda	p.h.				½	½	½	½					½		½							½	½	½	½	½		½	½	½		½	½	½	½	½					½	
Berkheya speciosa	a.h.														½																											
Blumea perrotiana	a.h.														½																											
Conyza schimperi	p.h.												½																			½			½							
Crepis carbonaria	p.h.												½								½	½	½		½					½	½										
Helichrysum cymosum	p.h.												½	½						½				½																		
" sp. 925	—													½																												
Lactuca capensis	—														½																											
Vernonia adsensis	p.h.														½																				½		½					
Crassocephalum crepioides	a.h.																						½	½																		
Helichrysum maranguense	shr.																							½																		
Schkuria pinnata	p.h.																																			½	½					
Vernonia karanguensis	p.h.														½			½															½					½				
CONVOLVULACEAE																																									
Dichondra repens	p.h.				½	½		½		½												½	½		½	½	½		½		½								½	½	
Evolvulus alsinoides	a.h.					½																																			
Ipomoea carica	p.h.																											½													½
Ipomoea sinensis	a.h.																																								½
Falkia canescens	p.h.																																			½					
CUCURBITACEAE																																									
Zehneria scabra	p.h.			½																																					
CYPERACEAE																																									
Cyperus denudatus	P.			½							½																														
" haspan	P.				½																																				
Cyperus latifolius	P.	½																																							
" rigidifolius	P.			½																		½			½																
Cyperus teneriffae	—								½																																
Fimbristylis complanata	P.			½		½	½	½	½			½																													
" dichotoma	P.	½	½			½	½			½	½														½							½									
" hispidula	P.					½		½	½																½										½						
Fimbristylis ovata	P.								½																			½		½		½									
" sp.	—					½	½			½											½	½									½		½	½		½					
Fuirena pubescens	a.				½																																				½
Kyllinga erecta	P.				½	½	½	½	½		½		½		½	½	½	½					½	½	½	½	½	½	½	½	½		½			½	½		½	½	½	½
" sp.	—				½	½	½	½	½	½	½	½				½									½	½			½							½	½					
Pycreus sp. 1033/596	—					½			½		½																			½											
Scleria nutans	P.						½				½																														
" sp. 1047a	—						½																																		
" sp.	—										½																														
Cyperus atrimus	P.																																							½	
" dichrostachyus	P.																																							½	
Cyperus platicaulis	P.																																							½	
Fuirena stricta	a.																																							½	
" ? abnormalis	—																																							½	
Lipocarpha chinensis	a.																																								
Mariscus keniensis	P.											½																													½
Pycreus flavescens	P.																																							½	
Scirpus fluitans	a.																																							½	
Scleria cf. barteri	P.											½																												½	
Bulbostylis densa	a.											½												½		½															
Mariscus sieberianus	—																												½				½							
Cyperus sp. 498	—																																½							
EUPHORBIACEAE																																								
Euphorbia inaequilatera	a.h.								½																											½					
" hirta	a.h.								½																																
Phyllanthus amaras	a.h.														½																										
" rotundifolius	a.h.						½				½														½								½		½						
" guineensis	shr.																																							½	
Acalypha villicaulis	p.h.														½																										
Phyllanthus sp. 893	—												½																	½		½									
Euphorbia schweinfurthii	p.h.																								½																
Phyllanthus sp. 727	—																							½																
" sp. 742	—																																								
GENTIANACEAE																																									
Sebea brachyphylla	a.h.																						½																		
GERANIACEAE																																									
Geranium arabicum ssp. arabicum	p.h.																																							½	


GRAMINEAE
B.F.
Brachiaria brizantha
" soluta
Chloris pycnotrix
Coelachne africana
Cynodon nlemfuensis
Dichanthium insculptum
Digitaria longiflora
" scalarum
" ? schmitii
Eragrostis atrovirens
" exaspera
" kiwuensis
Eragrostis schweinfurtii
" tenuifolia
Eleusine indica
Exotheca abyssinica
Harpachne schimperi
Heteropogon contortus
Hyparrhenia rufa
? Hyparrhenia sp.
Loudetia kagerensis
Leersia hexandra
Panicum atrosanguineum
Paspalum scrobiculatum
Pennisetum clandestinum
" hohenackeri
" thunbergii
Rhynchelytrum repens
Sacciolepis sp.
Setaria sphacelata
" sp.
Sporobolus molleri
" pyramidalis
" quadratus
Themeda triandra
Chrysochloa orientalis
Arundinella nepalensis
Digitaria pearsonii
Eragrostis volkensii
Hyparrhenia cymbaria
Panicum coloratum
" snowdenii
" trichocladum
Setaria atrata
Aristida adoensis
Digitaria diagonalis
Eragrostis sp. 1312
Hackelochloa granularis
Panicum maximum
" sp.
Perotis patens
Sporobolus stapfianus
Eragrostis panicifermis
" sp 1096
HYPERICACEAE
Hypericum peplidifolium
JUNCACEAE
Juncus effusus
LABIATAE
Ajuga remota
Leucas calostachys
Ocimum sp. C
" hadiense
" sp. 694
Plectranthus pauciflorus
Satureia biflora
Leonotis africana
Plectranthus sp 353
Salvia nilotica
Hoslundia opposita
Plectranthus longipes
Fuerstia africana
Ocimum sp. B
" suave

	B.F.	7	8	9	15	21	22	23	24	30	40	43	6	10	14	32	33	37	41	42	44	3	4	5	12	20	31	34	35	38	39	16	17	18	19	25	27	36	26	1	2	11
LILIACEAE																																											
Aloe laterita	p.h.																																										
Gloriosa superba	p.h.																							+/-					+/-														
MALVACEAE																																										
Sida alba	a.h.		+/-						+/-																							+/-										
" urens	p.h.								+/-																																		
Urena lobata	p.h.					+/-	+/-											+/-							+/-	+/-									3/-		1/-						
Hibiscus cannibinus	a.h.																																		1/-						1/-		
Sida rhombifolia	a.h.																																									
" cordefolia	a.h.																																			3/-						
" ovata	p.h.																																			3/-						
MELASTOMATAC.																																										
Dissotis senegambiensis	p.h.				3/-		+/-																								+/-									3/-		
speciosa	shr.											1/-																												1/-		
MENISPERMAC.																																										
Cissampelos pereira	p.h																																+/-	3/-	+/-	3/-						
Stephania abyssinica	p.h.			3/-			+/-																3/-																			
MIMOSACEAE																																										
Acacia abyssinia ssp. calophylla	trea						+/-								3/-																												
MYRTACEAE																																										
Psidium guajave	shr.						+/-																							+/-			+/-				1/-				
Syzigium guineense	shr.																																		+/-							
MYRSINACEAE																																										
Maesa lanceolata	tree														3/-																											
OROBANCHACEAE																																										
Eulophia calanta	p.h.											1/-																													1/-	
ORCHIDACEAE																																										
Orobanche minor	p.h.																							+/-	+/-																		
OXALIDACEAE																																										
Biophytum petersianum	a.h.					1/2	+/-		+/-	+/-	+/-																															
Oxalis corniculata	p.h.																							+/-	+/-	1%-																
" latifolia	p.h.																							+/-																			
" obliquifolia	p.h.																																		3/-								
radicosa	p.h.																																		+/-		+/-						
PAPILIONACEAE																																										
Alysicarpus rugosis	p.h.							+/-	+/-																								5/-									
" vaginalis	p.h.								+/-																												5/-						
Crotalaria sp. 292	-		+/-																																							
" sp. 575	-						+/-																																			
" ononioides	a.h.						+/-																																			
Desmodium hirtum	p.h.				+/-	1/2	+/-	1%							+/-			+/-								1%				+/-	3/-		+/-	2/-	+/-	+/-	3/-		1/-			
" sp. 1031	-									+/-																				3/-											
" sp. 605	-						+/-																																			
Indigofera brevicalyx	p.h.								3/-																																	
" subargentea	a.h.								1/0																																	
" sp. 1049	-								+/-																																	
" sp. 580	-						+/-																																			
Vigna parkeri	p.h.									+/-	+/-													+/-	1%-	2/-	3/0		+/-			3/-										
Indigofera sp.	-										+/-																															
Crotalaria sp. 1199	-																																									
" sp. 458	-											+/-																														
Trifolium usambarense	a.h																																									
Smithia elliotii	p.h.																																									
Crotalaria sp. 478	-												1/0																													
" sp. 987	-												1/0																													
Indigofera spicata	p.h.														1/-																											
" arrecta	p.h													3/																												
" sp. 899/889	-												1/-																													
" volkensii	p.h.												1/-																													
Alysicarpus glumaceus	a.h.																							1/-																		
Crotalaria incana	a.h.																							+/-	+/-																	
Indigofera sp. 846	-																																									
Trifolium baccarini	a.h.																								1/0																	
" semipilosum	p.h.																							1%		1/2		1/0		3/4	+/-										
Vicia pauciflora	p.h.																							+/-																		
" sativa	a.h.																																									
Zornia pratensis	p.h.																																									
Crotalaria cf. microcarpa	a.h.																																									
" sp. 979	-																																									
Desmodium barbatum	p.h.																																									
" luteola	p.h.																																									
Indigofera sp. 952	-																																									
" sp. 977	-																																									

	B.F.	7	8	9	15	21	22	23	24	30	49	29	6	10	14	32	33	37	41	42	44	3	4	5	12	20	31	34	35	38	39	16	17	18	19	25	27	36	26	1	2	11
Indigofera sp. 444	–																																		½								
" sp. 457	–																																		½								
" sp. 507	–																																	½								
Tephrosia linearis	p.h.																															½	½	½								
" sp. 741	–																																				½						
Zornia setosa	p.h.																																					½					
PEDALIACEAE																																										
Sesamum calycinum	p.h.																								½																		
POLYGALACEAE																																										
Polygala erioptera	a.h.																																			½		½				
" sphenoptera	p.h.																																			½				½		
POLYPODIACEAE																																										
Pteridium aquilinum	p.h.																							½																		
PRIMULACEAE																																										
Anagallis tenuicaulis	p.h.																						½																			
Lysimachia ruhmeriana	p.h.																																									
volkensii	p.h.																							½	½																	
RANUNCULACEAE																																										
Ranunculus multifidus	p.h.																																									
ROSACEAE																																				½						
Rubus apetalus	shr.																																									
Alchemilla cryptantha	p.h.																																									
RUBIACEAE																																										
Oldenlandia herbacea	a.h.				½	½	½						½		½										½								½	½		½						
Spermacoce princei	a.h.	½		½							½		½											½	½						½	½	½	½		½			½		
Oldenlandia goreensis	p.h.										½																												½		
" ? goreensis	?																																						½		
" monanthus	p.h.										½																												½		
Spermacoce sp.	?													½									½																		
" sp. A.	a.h.																								½																
Rubia cordifolia	p.h.																							½					½												
POLYGONACEAE																																									½	
Polygonum nepalense	a.h.																																								½	
senegalense	p.h.																																								½	
SCROPHULARIAC.																																										
Buchnera capitata	a.h.				½							½																														
Cycnium tubulosum	p.h.	½																																								
Veronica abyssinica	p.h.			½							½												½	½		½														½	½
Alectra sp. A.	a.h.																																							½		
" sessiliflora	a.h.										½																					½	½								
Cycnium jamesii	a.h.																																							½	
Veronica javanica	a.h.										½																														
Sopubia ramosa	p.h.																																							½	
SOLANACEAE																																									
Solanum indicum	shr.												½										½												½						
" indet.	?														½																										
Physalis peruviana	a.h.																							½																	
STERCULIACEAE																																									
Waltheria indica	p.h.																																½								
TILIACEAE																																									
Grewia similis	p.h.			½																																					
Pavetta sp. 919	?			½																																					
Triumphetta rhomboidea	p.h.					½	½	½		½					½										½	½						½	½	½	½		½		½		
" sp. 854	?						½																																		
" macrophylla	p.h.									½																															½	
" pentandra	a.h.														½																											
" sp.	?																															½									
UMBELLIFERAE																																									
Centella asiatica	p.h.			½		½	½	½	½	½	½	½			½								½		½	½	½	½	½	½	½	½	½	½	½	½		½		½	
Caucalis incognita	a.h.																							½																	
Hydrocotyle mannii	p.h.																								½																
VERBENACEAE																																									
Lantana camara	shr.					½																										½	½	½	½	½					
" trifolia	shr.																																					½				
Lippia grandifolia	shr.																																					½				
Lantana rhodesiensis	shr.																																½								
Lippia sp. 529	?																																½								
VITACEAE																																									
Cayratia ibuensis	p.h.																																		½						
Cyphostemma sp.	?																																		½						
" cf. nivea	?																							½																	
BARE SOIL %		20	4	0	0	5	1	0	3	4	2	5	8	6	1	0	10	9	10	0	0	1	2	0	0	1	1	2	0	1	0	5	5	4	2	45	15	1	20	0	40	0

Appendix 2:

Plot no:	Place:	Habitat:	Altitude:	Soiltype:	Coordinates:		number of species:	
7	Shartuka	Plain	1790 m.	Ppa	0,85 S	34,80 E	18	
8	Shartuka	hill	1820 m.	FQh	0,83 S	34,70 E	15	
9	Nyangusu	bottomland	1860 m.	BXa_2	0,54 S	34,51 E	24	
15	Oyugis	bottomland	1410 m.	BXa_1	0,32 S	34,43 E	20	
21	Rongo	plain	1430 m.	U_4Ghm	0,43 S	34,35 E	43	
22	Nyarach	bottomland	1340 m.	BXa_1	0,43 S	34,36 E	47	
23	Magena	plain	1300 m.	PXa	0,41 S	34,32 E	22	
24	Rodi Copany	plain	1375 m.	PBd	0,37 S	34,30 E	38	
30	Magena	plain	1300 m.	PXa	0,41 S	34,32 E	22	
40	Magenche	bottomland	1960 m.	BXa_2	0,75 S	34,44 E	23	
29	Magombo	bottomland	1835 m.	BXa_2	0,40 S	34,55 E	27	$\bar{x}$ = 27
6	Ramasha	steep-slope	1930 m.	U_1XhP	0,53 S	34,75 E	28	
10	Nyangusu	steep-slope	1835 m.	HXP	0,50 S	34,48 E	20	
14	Nyakongo	slope	1480 m.	HBhP	0,31 S	34,47 E	40	
32	Manga ridge	slope	1850 m.	U_1Qh	0,39 S	34,48 E	10	
33	Manga ridge	top	1890 m.	HXP	0,39 S	34,48 E	18	
37	Ranen	slope	1470 m.	HXP	0,53 S	34,36 E	18	
41	Nyangusu	steep-slope	1810 m.	HXP	0,83 S	34,49 E	14	
42	Nyangusu	slope	1830 m.	U_1XhP	0,83 S	34,49 E	12	
44	Ramasha	slope	1900 m.	U_1XhP	0,53 S	32,85 E	20	$\bar{x}$ = 20
3	Mwangoris hill	cultivated	1940 m.	U_2Ihn	0,41 S	35,15 E	25	
4	Nyamasibi	cultivated	1970 m.	U_1Ph	0,51 S	34,75 E	28	
5	Ramasha	cultivated	1930 m.	U_2Ihn	0,53 S	34,80 E	32	
12	Kisii	cultivated	1760 m.	U_2Ihn	0,43 S	34,50 E	32	
20	Rongo	cultivated	1390 m.	U_4GhM	0,45 S	34,86 E	41	
31	Nyachogochogo	cultivated	1870 m.	U_2Ihn	0,33 S	34,70 E	15	
34	Matongo	cultivated	1470 m.	U_3Ihn	0,38 S	34,43 E	16	
35	Matongo	cultivated	1580 m.	U_3Ihn	0,38 S	34,43 E	20	
38	Etago	cultivated	1550 m.	HBhP	0,54 S	34,40 E	19	
39	Magenche	cultivated	1850 m.	FQh	0,75 S	34,44 E	18	$\bar{x}$ = 24
16	Oyugis	fallow	1430 m.	U_4YhP	0,32 S	34,43 E	35	
17	Asumbi	disturbed	1490 m.	U_4Yhp	0,37 S	34,37 E	35	
18	Nyamatutu	fallow	1410 m.	U_3Gh	0,37 S	34,40 E	45	
19	Mogumo	disturbed	1520 m.	U_4Yhp	0,36 S	34,41 E	44	
25	Ligisa	fallow	1290 m.	U_4Yhp	0,32 S	34,33 E	30	
27	Achego	fallow	1300 m.	U_4Yhp	0,31 S	34,35 E	13	
36	Ranen	fallow	1450 m.	U_4Yhp	0,52 S	34,34 E	31	$\bar{x}$ = 33
26	Luora	bottomland	1350 m.	BXa_1	0,30 S	34,37 E	9	
1	Magombo	drained bottoml.	1835 m.	BXa_2	0,40 S	34,55 E	30	
2	Nyachogochogo	swamp	1850 m.	BXo	0,37 S	34,70 E	30	
11	Maji-mazuri	river-bank	1680 m.	BXa_2-BXo	0,52 S	34,47 E	26	$\bar{x}$ = 28

Appendix 3.

Sample plot numbers:	7	8	9	15	21	22	23	24	30	40	29	8	10	14	32	33	37	41	42	44	3	4	5	12	20	31	34	35	38	39	16	17	18	19	25	27	38
Paspalum scrobiculatum		5	1	0	25	20	30	30	+	15	22		4	5	+	+	+	5		10		4		5		30	27	4	15			30	10	70	60		70	65
Digitaria scalarum			+	10		1			2				1				5			+	1	5	4	0	+		20	20	40	8	5	5	5	3		3	10			2
Kyllinga erecta			8		7	5		3		2		1		2	+	+	+				2	2		+	+	1	+	2	2	1				+				+
Brachiaria brizantha					7	+					5				6				4	3					+							2		2			+
Dichantium insculptum					2	1	2	2			10				2	15		+							+										+		
Eragrostis kiwuensis									+			35									3											1	+				
,, schweinfurtii					1			+					+		1						2	5	10										+		5		
,, tenuifolia								2				4					2	2		5							5	+	10	6		4	5		18	8	5
Fimbristylis sp.					+	+			+										1	+										+			+	+			+
Cassia mimosoides					+	+	+	1	1					+									+		2			+			+	+	+				
Desmodium hirtum				+	+	1	10							+			2								15				+	2	4	2	+	+	5		1
Setaria sphacelata	5		1			+				+		3	2	2				+		+				40	2							+	+				
Eragrostis atrovirens	2		4		2				+	5	20		+			4	20	10		3																	
Kyllinga sp.				15	5	8	5	13	6	20	1	5				+									+		+		3								+
Pennisetum hohenackeri	7	0	3	0	40	30	25	20	60	40	50									5													10				
Fimbristylis complanata				5		4	2	7	6			4																									
,, dichotoma	2	+				3	2			8	6														+						+						
,, hispidula						+		8	5																+									+			
Eragrostis exaspera						+	+	+	1	+			1												+	+										7	
Hyparrhenia rufa				2	1	+	3	2							3																+		+				
Sporobolus pyramidalis	8					3	+	+	+											3					4							3		1	5		
Leersia hexandra		+							+																											
Crotalaria sp. 282	+																																			
,, sp. 575						+																														
,, ononioides						+																														
Desmodium sp. 1031									1																											
,, sp. 605						+																														
Indigofera brevicalyx								2																												
,, subargenta								1																												
,, sp. 1049								+																												
,, sp. 580						+																														
,, sp.										+																										
Sclaria sp. 1047[a]						+																														
,, sp.										1																										
Cyperus denundatus		2								2																										
,, haspan			2																																	
Panicum atrosanguineum					+																															
Pennisetum thunbergii			+																																	
Heteropogon contortus	3																																			
Cyperus letifolius	1																																			
,, teneriffae								2																												
Fuirena pubescens				6																																
Pycreus sp. 598/1038					+				2		+																									
Scleria nutans						+					1																									
Brachiaria soluta				10	5	22				4	5		2	5	20	25	1	+	25	3					+	+					10					5
Loudetia kegerensis		5				1						30	40	30	45	40	40	60	35	44																
Themeda triandra											+		20	30	30			2	1	2																
Exotheca abyssinica	6					+							10		2			1	5	10					+								3			
Digitaria diagonalis															+																					
Eragrostis sp. 1098																10																				
Hyparrhenia sp. 1312																	20																			
Crotalaria sp. 478												+																								
,, sp. 987												+																								
Indigofera spicata														1																						
,, volkensii												2																								
Pennisetum clandestinum		3					+					2								+2	6	1	1			2	9	4	0	3	6	0	7	0				
Cynodon nlemfuensis			+																	5	5	0	6	0	+			8	8	0	1	0					
Indigofera arrecta												2								1	+	+	+										1	0		+		
Vigna parkeri									+	+										1	1	0	2	3		+					2						
Alysicarpus glumaceus																					1																
Crotalaria incana																					+	+															
Indigofera sp. 846																					+															
Trifolium baccarini																						1															
,, semipilosum																					1	0			4		3	0	+							
Vicia paucifolia																						1															
,, sativa																					+							+								
Cyperus sp. 498																																	+				
Cassia decapetala																																			2		
,, sp. B																																					+
Tylosema fassoglensis																																			+		+
Rhyncheletrum repens					4																										1	0	5	2	2	5	
Digitaria longifolia					1												4								+							1		2	0	2	+
Aristida adoensis																																5		2			
Cassia sp. 982																																			+		+
Heckelochos granularis																															+						
Panicum maximum																															2						+
,, sp.																																	+				
Perotis patens																																1	+				
Zornia pratensis																																					
Crotalaria cf. micocarpa																																	+				
,, sp. 976																																					
Desmodium barbatum																															2						
,, luteola																															3						
Indigofera sp. 952																																	+				
,, sp. 977																																		+			
,, sp. 444																																		+			
,, sp. 457																																		+			
,, sp. 507																																	+				
Tephrosia linearis																															3		+	+			
,, sp. 741																																			2		
Zornia setosa																																					+

Based on a 1 - 100% coverage scale.

Appendix 4:

Plot no.	Gramineae			Cyperaceae			Leguminoseae			Rest		
	coverage	liked %	eat. %	coverage	liked %	eat. %	coverage	liked %	eat. %	coverage	liked %	eat. %
7	94	13	3	3	-	-	-	-	-	3	-	1
8	75	40	-	-	-	-	-	-	-	25	-	-
9	55	11	-	33	23	-	-	-	-	12	-	5
15	87	47	-	13	5	-	-	-	-	-	-	-
21	74	?	?	22	?	?	-	-	-	4	?	?
22	83	55	-	14	10	-	1	-	-	2	-	-
23	55	33	-	28	13	-	11	-	-	6	-	-
24	67	2	3	22	9	6	5	-	1	5	-	3
30	57	17	-	28	-	20	1	-	-	14	-	-
40	81	26	-	12	-	-	1	-	-	6	-	5
29	70	45	10	10	-	-	-	-	-	20	-	-
6	78	75	-	1	1	-	3	-	1	18	-	4
10	69	?	?	-	-	-	2	?	?	29	?	?
14	70	70	-	2	2	-	1	-	-	27	-	-
32	100	?	?	-	-	-	-	-	-	-	-	-
33	99	99	-	1	-	-	-	-	-	-	-	-
37	92	65	-	-	-	-	2	-	-	6	-	-
41	75	73	2	-	-	-	-	-	-	25	-	-
42	80	76	4	1	-	-	-	-	-	19	-	-
44	93	59	6	-	-	-	-	-	-	7	-	-
3	80	71	9	3	-	-	2	-	-	15	-	-
4	66	61	-	2	-	2	20	10	10	12	-	1
5	75	60	10	4	-	-	5	-	1	16	-	1
12	60	40	20	-	-	-	3	-	3	37	-	8
20	56	50	6	1	-	-	19	-	4	24	-	-
31	96	69	-	1	-	1	-	-	-	3	-	-
34	65	56	4	-	-	-	30	30	-	5	-	-
35	83	65	18	2	-	2	-	-	-	15	-	-
38	86	70	5	6	2	3	-	-	-	8	-	-
39	80	70	5	1	1	-	5	-	-	14	-	-
16	55	45	-	-	-	-	27	14	-	18	-	1
17	65	10	7	-	-	-	3	-	-	32	-	-
18	82	74	5	-	-	-	-	-	-	18	-	1
19	78	71	-	-	-	-	-	-	-	22	-	-
25	55	38	5	-	-	-	10	-	-	35	-	-
27	90	?	?	-	-	-	2	?	?	8	?	?
36	77	72	5	-	-	-	1	-	-	22	-	-